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opinion are relevant to developed countries generally. The special problems of the underdeveloped territories, however, are also examined—with a warning against certain popular misconceptions. The particular importance of the human element—managers, operatives and consumers—is stressed and the effects of education and specialist training analysed. In conclusion, a number of organizational and financial implications are outlined and methods for solving certain emergent problems suggested.

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RECENT DEVELOPMENTS IN ANIMAL BREEDING IN HOT CLIMATES

by
J. P. MAULE

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During the last thirty years developments in the field of crop production in the tropics—especially cash crops—have undoubtedly outstripped progress in animal breeding and husbandry. The reason for this is not far to seek; crops provide the essential food of the people, and, with the increasing emphasis on cash crops, more attention has been paid to them than to livestock, which are less reliable as a source of cash. There is, too, another angle: the land belongs to the people and can be freely cultivated, but livestock are possessions and a sign of wealth and prestige; any tendency to interfere with them—as for instance to encourage sales or eliminate unwanted males—usually meets with resistance. This attitude on the part of most of the cattle-owning people such as the Masai and Somali in East Africa, and the Fulani in West Africa, has made it difficult not only to raise productivity and improve the quality of livestock products but even to attempt any improvements or changes in methods of husbandry. The same difficulties are encountered in India where the Hindu beliefs prevent any worth-while improvements being achieved, due almost entirely to the excessive amount of overstocking and retention of large numbers of useless beasts.

In contrast to cattle, it is remarkable how thrifty and prolific are the goats which are so widely distributed in the tropics, and in Asia the water buffalo is a more economic producer than the cow.

With the rising living standards in many parts of the tropics and despite environmental conditions which are certainly not favourable to high productivity, there is an increasing demand for fresh milk, especially in India and in some areas in Africa. Meat is considered something of a luxury but tastes differ widely and whereas in some areas mutton is preferred (e.g., in the Sudan), in others (e.g. Ghana) the demand for beef cannot be met from local supplies. Moreover beef (whether on the hoof, canned or frozen) is more easily exported than milk, and in the ranching areas it may be the principal source of income.

The rising living standards in many parts of the tropics have focused

attention of late on the need to raise the output of livestock, both by improving the present low level of husbandry and, if possible, by introducing improved types of livestock. Some aspects of this will be considered and some of the problems associated with the breeding of better animals will be discussed.

THE INDIGENOUS LIVESTOCK OF THE TROPICS

Before considering improvements in tropical livestock, it is first necessary to describe their main characteristics:

1. Hardiness and adaptation to high temperatures and/or high humidity.
2. Resistance to many diseases to which temperate livestock readily succumb.
3. Ability to exist on poor quality food—and often with little water.
4. Low productivity and less well developed carcasses.
5. Slow growth rate and longer to reach maturity than temperate livestock, this being especially true of cattle.

By comparison with the highly developed European dairy cow, tropical cattle yield only about a fifth or a sixth of the quantity of milk in a lactation and give a carcass of less than half that of a European beef steer. Even with reasonably good management the yields of milk of practically all tropical cattle are well below those obtained from commercial herds in Europe.

On the other hand the water buffalo, which is native to Southern Asia, is an incomparably better dairy animal and good herds will average around 400 gallons (1,818 lit.) of milk containing 7 per cent butterfat, equivalent to a yield of 280 lb. (127 kg.) butterfat.

Most tropical cattle do not start to breed until they are 3-4 years old and in some regions cows do not calve until they are 5 years old, which is anything from 2 to 2½ years later than European stock. Likewise growth is not completed in most African cattle until they are 7-8 years old. They are seldom slaughtered for meat until they are over 5 years.

In conformation the zebu (*Bos indicus*) differs markedly from European cattle (*Bos taurus*). The hump, often more prominent in the male, the well developed dewlap, loose skin, and large ears were thought until recently to aid the animals to dissipate heat, but this has now been disproved. Its short-haired coat and dark skin are certainly advantageous in reducing the effect of heat and in minimizing the effects of solar radiation.

With few exceptions the zebu has not been developed in the tropics either as a dairy animal or as a beef animal and, in fact, many of the Indian zebu breeds, such as the Kangayam and Hallikar in South India, and some other tropical types of cattle, such as the N'dama of West Africa, have no inherent capacity to yield more milk than is required to feed a calf. Even among those 'breeds', or types, of cattle which are considered to be capable of giving milk for consumption, it is by no means uncommon to find cows which will not let down their milk, or some which give only minute quantities of milk. The ability

to let down milk except in the presence of the calf is unusual in tropical cattle, although many cows can be trained to do so. In size and conformation cattle vary considerably from the small West African cattle weighing only some 350-400 lb. (130-150 kg.) to the larger Indian breeds weighing over 1,300 lb. (600 kg.).

One of the features of the growth of topical cattle is that they will often lose weight during the long dry season and only begin to put on weight after the advent of the rains when there is ample grazing. These periods of shortage are typical of conditions and are a limiting factor in all forms of extensive husbandry.

This low level of nutrition, coupled with the limitations imposed by disease and poor management, and the conservatism of so many livestock-owning people, are the main reasons why productivity is low.

What then are the conditions necessary to bring about an improvement in productivity and what has been, or is being, achieved?

ADVANCED ANIMAL HUSBANDRY

There are four basic factors involved in the development of an advanced animal husbandry. These are: (a) a progressive livestock owner; (b) an improved standard of management; (c) an improved and efficient animal; (d) an assured market for the products. Without these it is impossible to raise the quality of livestock and increase production of milk, meat and other products. Due to the innate conservatism and the way of life of so many of the cattle-owning people, the possibilities of inducing a progressive outlook and willingness to adopt new ideas are limited, and this fact alone makes impossible any serious attempts at improvement in the productivity of their cattle. These restrictions, fortunately, do not apply everywhere. In and around large towns there is a steadily increasing demand for liquid milk, both in Africa and India. Moreover in other parts of the tropics where there is already a steady demand for milk and meat, and fewer scruples about the retention of cattle for their own sake, efforts to encourage a progressive attitude are more likely to succeed. Changing political and social standards may also help to break down prejudices about cattle and lead to more enlightened attitudes in the uses and management of livestock.

Provided there is a group of farmers willing to try new methods, the next step is to introduce improved management and this includes better nutrition, and especially provision of food at those periods of the year when grazing is scarce or non-existent.

A considerable amount of work is now in progress to establish permanent pastures and to find mixtures of grasses and legumes to suit different environments. Improved management is essential before there can be a successful attempt to improve the animal itself. Although possibly outside the scope of this article, the importance of good management must be stressed.

Advanced management implies a higher level of farming efficiency, proper feeding, calf rearing and hygiene. That it is possible to raise the level of production of ordinary stock has been shown in many different parts of the tropics, but the classic example is probably that of the Pusa herd of Sahiwal cattle in Northern India in which the daily average yield per cow was raised progressively from 5.8 lb. (2.6 kg.) to 18.9 (8.6 kg.) in 20 years. Admittedly there was some selection during this period but the major effect was due to improved management. Similar results have been obtained on government farms in India and Africa and elsewhere. An example of the effect of management on milk production of Jersey cattle is given by the following figures from Hope Stock Farm in Jamaica where four distinct periods in the history of the farm can be defined.

Effect of management on milk production in four distinct periods

		Average milk yield (gal.)	Average body weight of cow (kg.)
First period (13 years) 1910-23	Establishment of herd and pasture	358	403
Second period (10 years) 1924-33	Gradual improvement, better sires used	459	416
Third period (10 years) 1934-43	Rapid expansion and over-stocking, pastures deteriorated	390	380
Fourth period (5 years) 1944-48	Herd reduced to carrying capacity of pastures	593	397

BREEDING AN IMPROVED ANIMAL

There are at least three possible ways of raising the productivity of cattle in the tropics, given good feeding and management:

1. The selection of the best strains of indigenous breeds or types that are already adapted to a tropical environment.
2. The crossing of indigenous cattle with imported temperate zone or superior zebu breeds in an attempt to evolve an improved cross-bred type adapted to the environment and possessing a reasonably high productivity. Such an improved type may, in time, be expected to replace most, or part, of the indigenous population of a particular region.
3. The introduction and selection of strains of temperate zone cattle which show a high degree of adaptation and are highly productive.

The choice between these has in the past been very largely determined by environmental factors such as climate and disease, and by the type of livestock already existing in the country. Thus, where no indigenous cattle existed, as

in the West Indies, it was natural to import livestock, zebu cattle for draft and European breeds for milk and a great deal of cross-breeding between them has taken place. In West Africa both climate and disease have prevented any successful large-scale importations of livestock in the past, but, with the increasing demand for milk, and with improved economic conditions, there is now the possibility of introducing some European breeds.

In East Africa, European breeds do well in the temperate upland zones of Kenya and Tanganyika, and as a result some cross-breeding has occurred between them and the local stock. This has led to numbers of inferior dairy cattle finding their way to the coastal regions, and to Zanzibar Island where they are kept as long as they give some milk. The improvement of the indigenous cattle by careful selection and better management is extremely slow, but it is the only practicable course in areas where everything is against the introduction of an exotic breed or a cross-bred. The introduction of Cheviot sheep to the Bamenda Plateau of the Cameroons illustrates this. The pure-bred sheep failed to survive and there was little or no provision for the proper management of the cross-bred stock. Similar failures have occurred with imported breeds of cattle. Results obtained from selection work with indigenous cattle in Africa, and elsewhere, all go to show that with few exceptions tropical cattle are slow to mature, have short lactations and long intervals between calves, and give low yields of milk, often no more than 100-150 gallons in a lactation. These characteristics are not attributable solely to the influence of the environment but are due largely to the genetic make-up of the cattle.

It seems to be undisputed that superior genotypes for milk production are extremely rare in nearly all tropical cattle and progress in nearly every case of selective breeding in government-owned herds has been slow, if not negligible, once the effects of improved management have been accounted for.

Thus all the evidence we have goes to show that in areas where there is an expanding market for animal products, especially milk, and where standards of education are rapidly rising, the need for an improved animal must be met by the introduction of a superior breed. This is the position facing the agricultural and veterinary authorities in many territories today; as it takes thirty or forty years to evolve a new type of animal there is no time to be lost.

EVOLUTION OF ADAPTED AND EFFICIENT DAIRY CATTLE

A concerted attempt to breed an improved dairy animal has been in progress in Jamaica for the past forty years, but it is only within the last ten years that definite results have been apparent. Originally, cattle of most of the British dairy breeds were imported, and were crossed with local stock of zebu origin. Among the crosses, the F_1 Friesian-zebu gave the highest yields of milk but they were slow-maturing and less well adapted than the Jersey-zebu cross. The type finally selected contained about 75 per cent or more of Jersey blood

and also has some Sahiwal blood derived from one exceptionally good bull imported from India in 1920. This Jersey-Sahiwal cross is called the Jamaica Hope from the name of the farm where it was bred. The creation of this breed is the outstanding example of the evolution of a new dairy breed in the tropics and illustrates what an extraordinarily slow process this is. In the course of this work some families of both pure-bred and cross-bred Jerseys emerged which were particularly well adapted to the tropical environment. The conclusion was reached that in breeding an improved dairy animal it is essential to aim for one which shows a natural adaptation to the environment as exemplified by its ability to mature early, breed regularly and milk well. If any of these characters is lacking, then the animal is not fully adapted.

The Jamaica Hope herd at the government farm at Bodles now averages 700-800 gallons of milk per lactation and recorded cows in private ownership average 400-500 gallons. One cow in the Bodles herd has given a yield of over 2,000 gallons in one lactation, a yield seldom achieved in any country.

In Kenya a large-scale plan to improve the small East African zebu has been in progress since before World War II. It was realized that efforts to raise the yield of the local cattle to an economic level were not likely to be successful. The average yield of selected cows (chosen from a number acquired from the Nandi tribe) did not exceed some 250 gallons though individuals have given up to 500 gallons. The scheme involved the importation of Sahiwal bulls from India (and later from Pakistan) for crossing with the Nandi and other local types. The Sahiwal is the pre-eminent zebu dairy breed of the Indian sub-continent. Elite herds have given average yields of over 500 gallons and individuals had, before the last war, exceeded 1,000 gallons. Moreover the Sahiwal is a very docile animal and can be trained to let down its milk. Despite difficulties in acquiring sufficient breeding stock this scheme has progressed to the point where the demand for cross-bred stock by progressive farmers can barely be met and the yields of the first, second and third crosses (i.e., containing 50, 75 and 87 per cent of Sahiwal blood) are distinctly better than those of the selected local cattle and compare well with the yields of European cattle.

Average yields of milk in 1955-56

Type of stock	Yield
Indigenous cattle (on government farms)	250 gal. at 5.5 % = 137 lb. butterfat
Sahiwal grades	385 gal. at 5.3 % = 204 lb. butterfat
All recorded Ayrshires (in East Africa Milk Recording Scheme)	542 gal. at 4.06 % = 220 lb. butterfat

In 1958 the 1/2, 3/4 and 7/8 Sahiwal grades on government farms had average lactation yields of 341, 384 and 340 gallons respectively.

CROSS-BREEDING IN THE SUB-TROPICS

In some areas just outside the tropics where the environment is unfavourable for European dairy breeds, attempts have been made to combine the characters of adaptability in the zebu with the high milk yield of the European breeds. There are two examples of this, the results of which are in marked contrast. At Allahabad in Northern India, there has been in progress for some twenty-five years a cross-breeding experiment using imported Jersey bulls on Red Sindhi females. The Red Sindhi is a small zebu breed, considered to possess fairly good milking ability for a zebu. The cross-bred, containing approximately 50 per cent of the blood of each of the parent breeds, is called Jersind and has been selected for earlier calving and a satisfactory first lactation yield. The Jersind averages just over 400 gallons compared with about 280-300 for the Red Sindhi at Allahabad, and calves at 25 months compared with 38 months for the Red Sindhi. Although it is not yet a fixed type it could prove to be one well suited to many parts of Northern India.

In contrast with this is the experimental breeding carried out in the Southern United States of America to develop a heat-tolerant dairy cow in an area where the pure-bred European is at a disadvantage. This project aimed at introducing the adaptability of the zebu to European breeds by crossing them with Red Sindhi bulls (originally obtained from Allahabad in 1943). The work has been carried out at three centres, Beltsville in Maryland, Jeanerette in Louisiana and Tifton, Georgia, and both Jersey and Holstein cows were used, but the Jersey × Red Sindhi predominated. Although both the first and second crosses (i.e., with 50 and 75 per cent Red Sindhi blood) showed an advantage in heat tolerance over both the pure breeds (Jersey and Holstein) they did not compare with either breed in milk and butterfat production. The F_1 Jersey-Sindhi cross-bred gave 20-27 per cent less milk, and 14-22 per cent less fat than their Jersey contemporaries and the backcross to Red Sindhi gave approximately 50 to 60 per cent less milk and fat. Only the backcross to Jersey (i.e., 75 per cent Jersey) is at all comparable with the pure-bred and even it gave from 4 to 10 per cent less milk.

In the course of this work it was found that there was a noticeable amount of variation in the adaptability of the pure-bred cattle, and that lower heat production in cattle is more important to physiological comfort under hot conditions than the animals' ability to lose heat. This fact suggests that it should be possible, by minimizing physiological stress in dairy cattle, to avoid considerable loss of production.

Efforts are therefore likely to be made, both in the United States and in tropical countries, to select strains of 'European' dairy cattle with a high degree of heat tolerance.

THE PERFORMANCE OF EUROPEAN BREEDS

Up to some ten years ago the view was held that except in particularly favourable conditions, which included European management, it was not an economic proposition to breed European cattle in the tropics. In growth rate and conformation, calf mortality and productivity, the performance of these cattle compared unfavourably with that in temperate climates.

This view is gradually changing but the success of any attempt to introduce European cattle to a tropical environment still hinges on the endemic diseases and on the necessity to provide the best possible nutrition and management. Where beef cattle are ranched the effects of climate and inadequate nutrition are reflected in low calving percentages, poor growth rate and carcass weight. However, it now seems that climate is not necessarily a limiting factor to satisfactory performance. An experiment designed to measure the influence of the climate on growth and milk production of Jersey cattle was carried out in Fiji and New Zealand in 1950-51. One of each of 10 pairs of identical twin calves born in New Zealand was transferred when 7½ months old to Fiji. Both sets of calves were reared on similar food, and growth rate was recorded up to the end of the first lactation; the differences between the calves reared in New Zealand and Fiji were surprisingly small, amounting on average to about 10 per cent in liveweight just before calving, and only 3 per cent at the end of the first lactation. It was concluded from this that the poor development of European cattle in the tropics can be largely attributed to poor nutrition rather than to the effects of climate. This conclusion is borne out by the Jamaican work, referred to above, in which strains of Jersey cattle have grown normally and have given 'reasonable' yields of milk (the pure-bred Jerseys average between 600 and 700 gallons per lactation).

The work at Sigatoka in Fiji since 1948 has been aimed at the selection of heat-tolerant cattle which give reasonably high milk yields and a steady improvement has been obtained. A 'reasonable' yield of milk for European cattle has been put at three-fifths of the yield of similar cattle in temperate regions. Thus a 1,000-gallon cow in Britain would be expected to give 600 gallons in the tropics.

The superiority of the Jersey in heat tolerance is a fact noted by numerous research workers and one which should favour the Jersey in any future work directed towards the choice of a European breed for the tropics. It was also shown in Fiji that there is considerable variation within breeds in the amount of heat tolerance, some individual temperate zone animals possessing a degree of heat tolerance as high as that shown by zebu cattle. Nevertheless other European breeds have shown their ability to milk well and to adapt themselves to particular conditions. The Friesian has probably been most widely distributed in the tropics and on the whole gives the largest milk yield. Figures for milk yield vary but in small, well managed herds average lactation yields of

between 450 gallons (2,045 lit.) and 650 gallons (2,955 lit.) in 300-350 days have been recorded from a number of widely separated countries. However, the Friesian is, by comparison with the Jersey, slower to mature (first calving at 3¼-3½ years against 2½ for Jerseys) and has a longer interval between calves which suggests a lack of adaptation. But because of its higher milk yield and the extent to which it has already become established in some countries it is bound to play a large part in the future development of the dairy industry in the tropics.

The development of the Israeli Friesian during the past thirty years is a notable example of the way in which an adapted breed can be evolved. The basic stock used to develop the dairy industry was local and Syrian cattle giving at most 450 gallons. Crossed with imported Dutch Friesian bulls considerably higher yields were obtained and this led to the gradual upgrading of the local stock and to the pure breeding of Friesian cattle. Dr. Volcani of the Hebrew University has described[1] how the view was gradually accepted that it would be possible to breed Dutch Friesian cattle in the hottest parts, including the almost tropical areas of the Jordan valley. The success of this project is due largely to the high standard of management and feeding which the Israelis invariably give their cattle, and to the elimination of tick-borne and other diseases. Average yields of over 1,000 gallons (4,545 lit.) are now obtained throughout the country and individual herds in the Jordan valley have actually given over 1,300 gallons (5,909 lit.)

Other European breeds which have given good, or reasonably good, results in different parts of the tropics are the Guernsey, Red Poll and Swiss Brown. The last named is now well established in many South and Central American countries where it has become adapted to a wide variety of climates and to high altitudes. It is likely to extend its influence in Africa where small numbers are being tried in South West Africa and in Kenya.

One other type of dairy cattle deserves mention, namely, the Dairy Criollo of Central and Southern America. Criollo cattle are descended from the Spanish and Portuguese cattle imported to South America some 350 years ago. Cross-breeding with zebu or European breeds has taken place but the improved Dairy Criollo has no recent European blood. In appearance they are not unlike Jerseys but a special characteristic is their thick, tough skin which affords protection from biting flies. Yields of selected stock are still only about 450 gallons (2,045 lit.) with 4.6 to 5 per cent butterfat, but further improvement is aimed at and it seems likely that these exceptionally hardy cattle will have a place in the dairy industry in the humid tropical climate of Central America.

1. Address presented at the International Farmers Convention in Israel, April 1959.

BEEF CATTLE

The search for improved types of beef cattle for the tropics has revealed that certain zebu strains of beef cattle are better able to respond to the ordinary conditions of ranching than are European breeds; and on the other hand, the attempts to evolve cross-bred types combining the heat tolerance and disease resistance of the zebu with the superior carcass characters of the European breed seem to have met with a good deal of success. The best known of these new 'breeds' is the Santa Gertrudis which contains five-eighths European blood (mostly Shorthorn) and three-eighths American Brahman. But other crosses are now gaining in popularity, especially in the Southern United States and among these the Brangus (derived from Brahman × Aberdeen Angus) and Charbray (from Charollais and Brahman) are perhaps the most widely used, after the Santa Gertrudis. Brangus cattle are adapted to the more humid areas in the Gulf Coast area of the United States and they have also been exported to other countries on a limited scale. The Charbray is still in its infancy as a breed, but it appears to inherit from the Charollais the ability to put on weight. In a number of tests in Texas it has exceeded other breeds and crosses in weaning weight and shown exceptionally good liveweight gains during fattening. It is not unlikely the Charbray will compete with the Santa Gertrudis as a breed for areas where conditions favour large-scale beef ranching in the tropics or sub-tropics.

All these new types have been bred for particular conditions and of them only the Santa Gertrudis has been used in a variety of environments and, at present, only to a limited extent.

In the main beef-producing areas the breeding stock consists either of the indigenous cattle or of cattle with varying amounts of European blood as in Southern Rhodesia and Northern Australia. In tropical Australia it is only in recent years that an infusion of zebu blood has taken place as a result of the introduction of American Brahmans in the 1930s, and more recently of some Santa Gertrudis cattle. Already, however, the superiority of stock carrying some zebu blood is acknowledged and the breeding of a type containing about three-eighths zebu, called the Droughtmaster, is an indication that, as in the United States, one or more types suited to the environment will gradually be evolved.

One of the most striking things in cattle breeding in Africa has been the development of the Kenya Boran as a beef breed in its own right. The home of the Boran is in Southern Ethiopia and it was brought by traders to Kenya when the European settlers were extending their ranching operations in the 1920s. It is larger than many other types of cattle in East Africa and soon showed that it could compete, on Kenya ranches, with cross-bred stock derived from a certain amount of indiscriminate breeding between the small local cattle and European or grade bulls. In 1950 a Boran Cattle Breeders Society

was formed and there are now well over a thousand registered cattle, conforming to the type and characteristics laids down for the breed in Kenya. The Boran does extremely well in ranching conditions and steers can be ready for slaughter at about 4 years old without any supplementary feeding. At this age top-grade carcasses will weigh as much as 540-580 lb. and in exceptional cases well fed steers have given carcass weights of 600 lb. at 3 years. Boran cattle are very hardy and are easily handled—which contrasts with zebu cattle in some other parts of the world—and they have the merit of being regular breeders with calving rates of at least 80-90 per cent.

There is no doubt that among East African zebu cattle the Boran is an outstanding beef breed, and some strains have also shown an encouraging ability to milk well and will play an increasing part in ranching schemes in East Africa, and possibly elsewhere, for the breed is doing well in Tanganyika and has been exported to Northern Rhodesia and the Congo.

ARTIFICIAL INSEMINATION (A.I.) IN THE TROPICS

This method of breeding has become established practice in many European countries, including Russia, and in North America, but it is used only to a very limited extent in the tropics where there are a number of difficulties and disadvantages in developing it widely. These difficulties mostly concern the organization of an artificial insemination service in conditions where cattle are not under control, oestrus is not easily detected and the technique of insemination is regarded as something uncanny by the cattle owners. But where there is a small but intensive dairy industry, and where European or cross-bred cattle predominate, the introduction of A.I. has been successful and is slowly expanding, as in Kenya, Jamaica, Mauritius and India.

The advantages of A.I. lie firstly in the fact that the maximum use can be made of a small number of good bulls. This is of special importance where imported bulls are used, or where bulls which have been progeny tested are required to be used as widely as possible. Secondly, it is a means of reducing or eliminating the spread of disease, especially that associated with sterility. It was because of the occurrence of cervico-vaginitis and epididymitis in European cattle in Kenya that an A.I. service was developed there. In 1958 over 100,000 doses of semen were issued from the central A.I. station at Kabete in Kenya. Thirdly, A.I. has great potential value in the introduction of exotic breeds to the tropics by the importation of frozen semen rather than of expensive bulls. At present, however, the export of semen from Western countries has been carried out only on a small scale but trial shipments to several parts of the tropics indicate that this is likely to be a potent means of introducing genes for high milk production to the indigenous or local cattle in the tropics.

It is in the use of outstanding bulls that A.I. offers the greatest opportunity for improvement of the cattle of a country; whereas by natural breeding a bull

will sire at most 100-200 calves a year, by artificial insemination one bull can be used to breed ten or twenty times this number. Furthermore it is possible to extend the use of bulls which are normally shy or sluggish breeders; by means of the technique of electro-ejaculation, semen can be obtained from such bulls, or from bulls too old or otherwise unable to mount a cow. When correctly applied this technique causes neither damage nor pain to the animal and the quality of the semen is equal to that obtained by the normal method of collection.

It has now become established practice in Britain and other countries to use artificial insemination as a means of carrying out progeny tests of selected young bulls. Sufficient cows can be inseminated within a period of 3-4 months to enable some 20-30 daughters to be tested by the time the bull is about 5 years old. The average yield of each bull's group of daughters when compared with that of their contemporaries (i.e., all other heifers in the same herds milked in the same year) is a measure of the bull's breeding value. Similar tests, if used for instance in conjunction with the large-scale breeding scheme in Kenya to improve the indigenous cattle by grading up with imported Sahiwal bulls, should materially assist in identifying superior bulls. This is a facet of animal breeding which has hitherto not received sufficient attention in most tropical countries, but its successful application depends very much on proper milk recording, without which no accurate estimates of breeding value are possible.

SHEEP BREEDING

With the exception of the merino sheep in tropical Queensland, parts of Africa and of the coarse-woolled breeds in the Indian subcontinent and Western Asia, most of the indigenous sheep in the tropics are the short-haired, mutton type. Apart from the merino and with a few exceptions, the introduction of woolled breeds for crossing with the hairy or coarse-woolled sheep has not been successful, due to the susceptibility of the imported stock to parasitic diseases. Thus, apart from the few areas where imported woolled breeds thrive, as for instance in the Kenya highlands, parts of South America and the more favourably upland areas of India and Pakistan, most of the attempts at improvement have been concerned either with the coarse-woolled breeds (as in India) or with attempts to evolve a non-woolled mutton breed of better conformation, which retains the hardiness of the indigenous sheep and their ability to grow without supplementary feeding.

Experiments in this direction have involved either the introduction of an exotic breed, such as the Dorset or Wiltshire Horn—the latter being the only non-woolled British breed—or the selection of an indigenous mutton breed, such as the Lohi in Northern India, or some of the African sheep.

The Wiltshire Horn has not, on the whole, proved successful in the tropics, and in most cases the pure-bred stock have failed to thrive, nor has the small

number of first crosses fared much better. It is, however, too early to say whether the attempts being made in the West Indies and in Southern Rhodesia have failed. In the latter a strain of Wiltshire Horn × Blackhead Persian seems likely to become established. The cross between the Dorset Horn and Blackhead Persian which has been developed in South Africa, with the name Dorper, is now well established there and gives a more acceptable carcass with less fat than the Blackhead Persian with its excessively fatty rump and dewlap. In the semi-arid regions of Southern Africa, the Dorper may in time replace the Blackhead Persian except in the very driest areas. Similar attempts to evolve a cross-bred sheep from the Dorset Horn are being made elsewhere, notably in Uganda.

The main problem in sheep husbandry in the dry tropics is one of nutrition rather than breeding. Local taste for mutton differs and the production of the well fleshed, lean type of mutton lamb preferred by Europeans is not only unsuited to the environment but is not in demand by the local inhabitants. The emphasis is therefore likely to be on a sheep which will make better growth under favourable conditions but which must be able to survive the disease hazards and the unpredictable food supply.

In the humid tropics, sheep husbandry is of minor importance but it is in many of these areas that the demand for meat is rapidly increasing, i.e., in West Africa and the West Indies and where it might be supposed that small-scale sheep husbandry would be a useful adjunct to other farming activities. It is here it seems that there is scope for investigation of methods of husbandry to suit the conditions. In the West Indies where there are few sheep the demand for mutton cannot be met from local supplies, and quantities of frozen mutton and lamb are imported. Most of the sheep have been derived from importations from West Africa or South Africa (the Blackhead Persian) and there is clearly an opportunity here to investigate the possibilities of extending sheep and goat husbandry to meet the demand for meat.

One of the main limitations to increased production in the tropics is the low fertility (often coupled with high mortality) which is common. Many of the tropical sheep have only one lamb a year for twinning is rare, but in some cases two lamb crops can be obtained in one year, or, as in Western Nigeria, three crops may be bred in two years. By comparison the lamb crop in merinos in Northern Australia is often as low as 50 per cent (i.e., only one lamb to every two ewes capable of breeding). The possibilities of increasing the numbers of lambs born and of rearing a high proportion of these clearly require further investigation in tropical mutton 'breeds'.

GOAT BREEDING

No article on animal breeding in the tropics would be complete without some reference to the improvement of goats. These ubiquitous and useful animals are often considered to be more of a nuisance than otherwise because of their

destructive habits in forests and other areas planted with trees. Nevertheless the goat *is* a most valuable animal providing a considerable amount of meat, some milk and in many cases a valuable skin. The best indigenous milch breeds are found in India, the best known being the Jamnapari which has been widely exported within Asia. In the West Indies a useful dairy goat has been developed from introduction of European breeds such as the Anglo-Nubian, British Alpine and Toggenburg. Goat keeping is confined to the small farmer to supply his household requirements but yields of over 1 gallon a day have been obtained.

Most of the work in Africa has been towards improving the quality of skins by educating the African to cure them properly. The quality of the Sokoto goat skin from Nigeria and Mubende skin from Uganda, is already highly regarded in the glacé kid trade and every effort is made to maintain the high reputation of these two types. Efforts are also being made to improve meat output by an increase in size and in prolificacy, since many of the goats are small, and more than one kid per pregnancy is unusual.

In Tanganyika the cross between the indigenous goat and imported Boer goats from South Africa gives a large goat which thrives well in the dry area of the Central Province, but on the whole the problem is again one of nutrition.

PIG BREEDING

From the point of view of meat supplies, pigs offer considerable opportunities for a rapid increase, especially where there is a favourable market. Although some 40 per cent of the world population is in the tropics, the distribution is very uneven, the greatest concentration being in the Far East (Southern China, Thailand, Malaya and the Philippine Islands) and in Brazil, whereas in the whole of Africa there is only 3 per cent of the tropical pig population, and even less in India.

Despite this, however, some interest has been aroused in developing pig breeding in countries such as Malaya, Sierre Leone, Nigeria and Kenya. There is a good deal of evidence to show that provided they are given plenty of water and some shade, pigs do not suffer unduly from high temperatures. Feeding is all important for though the pig is omnivorous, it will only fatten economically and give a satisfactory carcass if fed some good quality concentrated foods.

Most of the investigations, therefore, concern feeding and rearing and the choice of breed is usually easily decided. Of the British breeds that have been exported to various parts of the tropics the early maturing pork type such as the Berkshire and Middle White has been used extensively and also the Large Black. Some research on developing hybrid pigs is in progress at Ibadan in Western Nigeria (using three-way crosses) and in Singapore where crosses between the Chinese and British breeds (probably Middle White) containing

62 per cent of British blood will reach market weight in 19-20 weeks, compared with 32 weeks for Chinese pigs.

CONCLUSION

This review of animal breeding in the tropics has endeavoured to emphasize two important problems confronting the animal improver:

1. That the generally low level of husbandry prevents any spectacular or rapid improvement in the indigenous types of livestock. As control of diseases and nutrition improve some increase in total production can be expected, and in fact is already becoming noticeable, but the production per head is not likely to rise significantly.
2. To achieve an increase in productivity per animal requires the introduction of existing breeds from temperate countries coupled with a much higher level of husbandry. By selecting British breeds of cattle in the tropics there seems little doubt that in time adapted types will be developed. The few examples we have all tend to show that economic yields can be obtained, especially from dairy cattle.

Although the second must continue to be a major objective in animal breeding, especially in areas where disease conditions and climate favour the better animal, nevertheless it must also be the aim to improve the best of the indigenous breeds so that productivity in terms of increased fertility, carcass weight, milk, eggs and skins will rise at a rate sufficient to meet the increasing requirements of the inhabitants of the tropics.

FORESTRY—A WORLD PROBLEM

by
K. H. OEDEKOVEN

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After graduating in 1938 he worked in the Central Forest Office, Berlin, in the State Forest Service of Lower Saxony and in the Forestry Division of the Federal Ministry for Food, Agriculture and Forests at Bonn. For the last 20 years he has devoted much time to the problems of world forestry. In 1958 he held the office of Vice-Chairman of the European Forestry Commission.

As far back as the unknown origin of mankind the path of human activity has been marked by the thoughtless destruction of forest and vegetation. In the course of history civilizations have flourished and disappeared, with a resultant depletion of trees and plants, to leave only steppe and desert behind them. Only in recent centuries man has realized that he was cutting off the branch on which he was sitting. He has become aware of nature's vengeance and, at the same time, of the challenge not only to preserve his dwindling assets but also to expand the very basis of his existence—the fertile earth—as the demands of a growing population become more and more insistent. The forest, the largest and most durable soil cover, which was once regarded only as an obstacle to settlement, agriculture and communications, and therefore recklessly burned or exploited, suddenly became a focus of intense interest. It was learnt that the two most important elements of our existence—soil and water—owe their stability and availability to the presence of sufficient forest cover, and in many countries this awareness did not remain confined only to a few informed specialists, but eventually became common knowledge to every citizen. After a visit to the denuded mountains of Natal, the Prime Minister of South Africa, Jan Smuts, declared in the Parliament: 'This is the vital problem of our people, it is more important than all politics!' In some distant future, this change of mind, this great turning back from the destruction of forests to reafforestation, may perhaps appear to the historian as a more important landmark in the development of mankind than all the great wars of our age.

But awareness alone does not solve the problem. The ministers of agriculture in most countries are deeply perplexed. World population is increasing by more than 50,000 people daily but the available area of productive land is still steadily on the decline. Three-quarters of the world's population are

undernourished. There are only 0.4 hectares of land per head for food production, and no less than twice this area is needed to ensure satisfactory nutrition. The true Enemy No. 1 in the world is not a political or military opponent but the deterioration of the soil, the dryness, the irresistible progress of semi-deserts and deserts. In some countries, like the United States of America and the Union of Soviet Socialist Republics, soil conservation has become sort of a 'State religion'. In Southern America, all over Africa, Asia and Australia there is great concern over the manifold dangers which threaten the soil. While international rivalries change, while political leaders come and go, this destructive process of soil deterioration remains a permanent menace. Each government inherits this burden from its predecessor and still, at the present day, the efforts of many countries to remedy the situation are merely in their infancy.

It was only a few years ago that the streets of Swakopmund in South-West Africa were swept over by a sandstorm that piled up sand dunes 6 metres high. We know from the experience of 500 years that the Sahara desert progresses towards the south at the rate of a metre a year on a wide front of 3,000 kilometres. Lake Chad, which, some decades ago was still an ideal refuge for migrating birds from Europe, is steadily diminishing in surface area and depth and its shores are turning from fertile green to a steppe brown. All far-reaching plans for the development of Africa as the 'Continent of the Future', all plans for water use and industrialization, will fail unless the necessary attention is paid to the importance of trees and forests.

If we try to classify the great list of lost or endangered productive lands we shall find first that two extensive desert belts have developed along both sides of the equator. The one in the south reaching from Australia to South Africa and South America, the other one in the north from China, all across Asia, North America and Mexico.

The northern belt includes those nations which, as we learnt in our history classes at school, were once the rulers of the world. We were puzzled to hear, in geography class, that large areas of these once powerful countries are sterile. But the truth is, of course, that in ancient times they were not so. Ctesiphon and Baghdad, once centres of concentrated power, were described by Herodotus more than two thousand years ago: 'Of all the countries we know this is the most suitable for growing grain. It is so well favoured that it yields two-hundredfold and, where conditions are best, even three-hundredfold. The ears of wheat and barley grow to the width of four fingers. But to the height of what tree millet and sesame grow I shall not disclose, though I know it exactly. No one who has not seen Babylon would believe me.'

So, for Herodotus Babylon was the essence of fertility. But he also accorded the same honour to Cinyps, a region in North Africa: 'This country produces grain equal to the best I have seen, for it has black soil and springs water it. The yield is equal to that of Babylon, three-hundredfold under the best

conditions'. Soldiers in the sand and torrid conditions of this region (part of modern Cyrenaica) during the last war must have had difficulty in imagining that a now desolate desert was the richest of farming land two millenia ago.

Mankind has lost a considerable part of its cultivable soil during the course of recorded history, and through this process nations which once ruled the world, have gone down to poverty and misery.

We can distinguish three zones on the globe which successively were the homes of dominating civilizations and where the soil has become progressively devastated in proportion to the time that has elapsed since they were first settled.

First zone. In the Sahara hundreds of archaeological finds and cave paintings indicate that this was once a flourishing country with many lakes and rivers. One of the cave paintings shows men swimming—imagine swimmers in the Sahara desert!

Second zone. From West China, Turkestan, Afghanistan, Iran, Iraq, Jordan, Sinai up to North Africa, we find a continuous range of stone, salt, and sand deserts. In ancient times, these latitudes were inhabited by Sumerians, Babylonians, Persians, Macedonians, and Phoenicians—names which are all connected with world power and wealth.

Third zone. Palestine, Syria, Asia Minor, Greece, Italy and Spain. It is true that the Southern European States, Greece, Italy, and Spain are neither steppes nor deserts, nevertheless their deforested mountains justify the statement once made by Henry C. Wallace, United States Minister of Agriculture: 'Nations live as long as their humus!' These countries, to which for centuries numerous foreigners came in search of fertile land, nowadays see their own inhabitants emigrating to all parts of the world to find better living conditions.

Zones of depleted land extend slowly from the south to the north, and this epidemic of devastated soil seems to be a contagious one. Attempts at reafforestation in Spain, Italy and Greece would certainly have been more successful had the opposite shores of the Mediterranean still been covered with a wide belt of fertile land as once they were. But the terrible desert has already reached the shore of the Mediterranean on a wide front and sends out its drying winds to the European countries. The ever-blue sky of Italy has not always been as blue. Some 2,000 years ago it was just as grey and cloudy as in northern parts of Europe and the complaints of the old Romans about frost and snowfall—which seem so strange to those who know Italy today—were probably justified.

This short review of former times and conditions is an attempt to show that much of the world's population (except in East and South Asia) has left its earlier home and shifted more and more to the north. What caused this change from paradise to desert? Is this dreadful development an unavoidable destiny or is man himself to blame for it?

While once it took millenia or at least centuries to deplete fertile land, modern history offers a striking example of how man can start and complete this disastrous chain-reaction in only a few decades. Hardly a hundred years ago the American farmer moved into the Middle West, full of initiative and energy. In the beginning the existing forests seemed inexhaustible. They were cleared, houses and bridges were built, the wood was burned in locomotives, on ships and in stoves. Great quantities were even felled and burned on the spot to make large areas of ash-fertilized farming land. A little later, monocultures and tractors caused even the last surviving clumps of trees and hedges to disappear. As a result, water ran off too rapidly, the soil was eroded, floods occurred and drought appeared between rainy periods. The process was even accelerated during the first world war when large areas of the remaining tree-covered prairie were ploughed for more intensive wheat production. Part of this land was left idle after the war, but there was no longer any deep-rooting grass or other soil cover to conserve the moisture and stabilize the soil. The storms coming from the Mexican Gulf and Canada swept the land unchecked—there were no forests to break their force. The wind carried away the fertile topsoil and only the sterile layers and rocks remained. The same damage was done to the former forest areas, now denuded. Without the protection of the trees, without the firm grip of their roots, without humus, the soil was carried away. In the south, where the frost which usually stabilizes the soil during winter seldom occurs, and where no snow-cover could prevent the damage, soil and wind erosion had the same detrimental effect. Like a network of veins the first slight gullies appeared in the soil, finally deepening to real gorges. The process was repeated a million times all over the country until finally only the naked rock was left in some regions. Even today American rivers carry away so much fertile soil that an old Indian once said: 'Our country is a new Atlantis; one day it will have disappeared in the Ocean!' It is significant that the Americans, aware of their responsibility for this destruction of productive land, call their deserts 'man-made deserts'.

If we were to set out to summarize the direct repercussions of the destruction of forest land on human society the list of wasteful and harmful effects would be a long one: soil deterioration, increased difficulty of watershed management, climatic deteriorations, lack of wood for the many purposes which it fills in man's daily life, heavy expenditure for imported timber, loss of the employment and income which forests and forest industries naturally provide, shortage of recreation areas, loss of additional income from small woods which protect farmers against crises and failures, lack of shade for livestock and animals; to mention only a few. And each of these effects sets off a whole chain of other negative reactions which we cannot consider in detail in the limits of this article. It therefore seems to me more opportune in this context to suggest possible remedies and to outline what ought to be done in a positive direction.

To state the matter in general terms, all measures and efforts must be

combined and incorporated in a sound forest policy. This simply means: defining for each country the role that the forests, primary forest industries and ancillary activities must play in relation to the physical, economic and social environment. The physical environment alters little with time. But economic and social conditions, on the contrary, may change as a country seeks to improve the living standard of its people. Hence forest policy must also be a continuous creation. This is all the more difficult since the objectives set are for the future, and it always takes a long time for any action on the forest to show appreciable results.

It is only logical and natural that the formulation of a forest policy will vary from country to country, as local conditions and requirements vary. There are, however, some basic principles which will serve as general guidance everywhere. They can be formulated as follows:

Sustained yield management. The forest policy of each country should be directed towards the creation and conservation of a proper forest area and towards the exploitation of these forests on a sustained yield basis.

Land use. The best land use will only be ensured if there is a balanced relationship between forestry, agriculture and range management.

Soil protection and watershed management. In order to protect the soil and regulate watershed management, the establishment of special protection forests is justified, even where the economic yield from these forests is of lesser importance.

Forest protection. Effective measures should be taken to prevent forest fires, over-exploitation, shifting cultivation, uncontrolled grazing, and other destructive activities.

Wood consumption. Forest industries and, to a lesser extent, private individuals should arrange their wood consumption so as to ensure most economical use and complete utilization.

Forestry education. Proper training facilities for an adequate number of foresters should be provided.

Forest research. A well conceived forest research programme should be established in conformity with project priorities.

Forestry publicity. Steps should be taken to make the public forest-minded.

Over-all importance of forestry. Forestry should never be an isolated science or practice, but always be considered in relation to the requirements of the national economy and the general welfare of the people. It should ensure full benefits from all the productive and protective influences of the forest and produce such amounts and qualities of timber as the national industries and other consumers require.

The investigation, not to say the full recognition, of the *protective* or *indirect* influences of the forest is a comparatively young branch of study. The interrelations are extremely complex and it is no surprise that our technical age has greatly neglected them. Is it not a common observation everywhere, for

instance, that schoolchildren can identify almost any type of automobile at a glance but are often unable to distinguish an oak tree from a beech? It is thus all the more necessary to inform the public of the beneficial functions of trees in nature.

The following outline may give some idea of the multiple indirect effects of the forest.

PHYSICAL CRITERIA

INFLUENCE ON SOIL

Erosion. One of the most important actions of the forest is probably the prevention or reduction of soil erosion—though it is true that a complete elimination of erosion cannot be expected since it is part of the universal natural process whereby the earth's relief is slowly moulded. This protective action is mainly a result of the fact that forest cover increases the degree of infiltration of precipitation and checks run-off. Even small forest plants like shrub and bush in hot arid regions offer valuable defence if they are reasonably dense.

The degree of erosion depends largely upon the stocking capacity of the forest, upon the texture of the soil and the gradient of the slope. Undisturbed natural forest canopy and floor therefore maintain infiltration at a maximum and keep erosion down to a minimum. We should not, however, conclude from this that forests on slopes and soils which are liable to erosion should be left as they are and not be subject to planned forest management. It should also be kept in mind that over-grazing in forest areas causes continuous trampling, thus hardening the topsoil and reducing its permeability.

In many parts of the world where forests have been destroyed or depleted all the fertile humus and topsoil has been washed away and only the sterile rock has been left on the slopes. And not only are these slope areas condemned to sterility, but also vast surfaces in the valleys and plains are often overlaid with sterile sedimentary matter—not to speak of the damage to installations such as roads, buildings, etc. If we could assess the cost of such losses and of the outlays involved in repairing the damage done by erosion in the world today we should be faced with a figure of incredible magnitude.

Silting. But erosion itself is only the first phase of a serious chain reaction which starts with the regression or disappearance of forests. Sediment deposited in reservoirs, water-courses, fields and cities is an important part of the total damage. This is a process which does not, as a rule, come to public attention since it is often invisible. Sediment also increases the total volume and weight of flow in water-courses, thus raising the height of their flood peaks and their

destructive power. In drainage basins and reservoirs debris and sediment can reduce the water capacity in a short time. According to investigations into the effect of silting on the capacity of dams in Algeria, several dams lost 100 per cent of their original capacity in a period varying from 74 to 96 years. Similar findings with respect to annual storage depletion in numerous dams in the United States indicate that from 0.09 to 31.53 per cent of original storage capacity is lost as a result of silting. A recent monograph on the Arno river basin in Italy reveals that 2,670,000 tons of solid material are carried away annually by the water flow, thus causing an average lowering of land surface of 2.5 cm. a year.

Silting is nearly always associated with deforestation, whereas dams which are fed from almost completely wooded watersheds practically never silt up. Experiments carried out by the Tennessee Valley Authority in 1955 showed that after the reafforestation and protection works had been completed, the volume of sediment carried down by the river was reduced by 90 per cent. The Bini-Bahdel dam in Algeria, where the catchment area is covered with forests, shows hardly any evidence of silting.

Soil improvement. The effect of the forest on the reconditioning of already deteriorated soil must also be taken into account. There are many examples where agricultural crops on forest clearings dwindle rapidly from year to year whereas the surrounding forest vegetation shows little evidence of degradation. The main reasons for this are the deep root system of forest trees and the steady feeding of the upper soil layers by plant waste. The soil improving effect of the forest becomes especially evident where poor quality wasteland has been afforested; in some cases even after one rotation the soil is found to be markedly improved in quality. Naturally, this depends to a very great extent upon the right choice of tree species and the silvicultural system adopted. In the northern hemisphere, large areas of valueless peat bogs have been converted into productive forest soil after afforestation. Impoverished land in the arid zones has also been made productive again by the provision of some forest cover.

Stabilization of soil and dunes. The forest plays an important part in protecting the soil against wind erosion and sand encroachment. Dune stabilization by tree planting is a well-known practice in many parts of the world. It is true that almost any vegetation cover will stabilize loose soil and prevent it from being eroded by wind and rain, but forests are probably more effective than any other because of their height, density, and deep-reaching roots and also because of their permanence as compared to agricultural crops, which cover the surface for only a limited time.

Soil temperature. The forest cover attenuates soil heating and radiation not only according to the type and density of the cover, but also according to the

properties of the terrain. This influence is important because it affects the top-soil horizon in which very significant biological processes take place. The influence of the forest in reducing maximum soil temperature is due partly to the shade of the crowns and partly to the insulation of the forest floor. The monthly minima of soil temperature in the forest are generally higher than in the open. These are the general findings from a large number of exact measurements in different forest types in various regions.

INFLUENCE ON CLIMATE

Rainfall. It is a keenly debated question whether the forest can bring about increased rainfall or, at least, make for its better distribution. We must distinguish between local influences and long-term action. Local influence depends mainly on the effect which the cooling of the air above the forest may have in modifying the saturation deficit, independently of any increase in humidity in the air above the forest. There are indications that the presence of forests may increase local rainfall, though effects on a regional or continental scale have not been demonstrated.

Increase in atmospheric moisture content. Increased atmospheric moisture content in forest areas is a result of loss of water from the trees. This movement of water from the soil through the tree to the foliage is a natural process in the life of all vegetation and no growth or increment would be possible without it.

Reduction of wind velocity. The denser the forest the greater will be its power to reduce wind velocity.

Kittredge in his work has proved this protective effect of the forest and noted reductions in velocity of over 85 per cent. Pavari mentions that in Italy the Cecina forest reduced wind velocity by 56 per cent and a hardwood coppice in the same region was responsible for a reduction of 89 per cent. Experiments in Tennessee, USA, show on an annual basis that the reduced velocities are usually between 20 and 50 per cent of those in the open. The importance of such protection against wind erosion can hardly be exaggerated. In dry periods and on bare land the particles of certain types of soil become so severed from each other that a strong wind can easily carry them away. The finer particles form clouds, and the coarser particles, whipped by the wind, roll and bounce over the surface of the soil. Their movement—especially the movement of the coarser particles—is halted wherever the wind slackens. They bank up in pits, ditches, canals or sunken roads and in the neighbourhood of sheltering objects where they may suffocate the crops. But this is only one of the perils which result from strong winds. Drying out of the soil, direct damage to delicate products like fruit and the distortion and stunting of exposed single trees can all be traced back to this cause.

Forest protection can not only prevent damage and loss, it also has the positive effect of increasing the yield of adjacent agricultural crops, as has been proved by a great number of experiments.

Modification of the extremes of air temperature. In varying degrees the forest affects air temperature. The sun is the chief source of heat for the air and also for the surface layer of the soil from which the convection currents of heated air rise. Though usual weather records at official stations are obtained from instruments carefully placed so as to avoid any influence of trees, a number of experiments have also been carried out with the specific object of determining climatic conditions in the forest. Summing up the available findings we may state that the forests have a noticeable influence in modifying the extremes of air temperature, although this influence cannot be expressed exactly or in terms of universal applicability. Compared with open areas, the largest divergencies thus caused are found close to the ground. Altogether, the reduction of maximum and minimum temperatures is confined almost entirely to the forest itself and influence on neighbouring areas is rather limited.

Soil radiation and light. When radiation or light intensity is measured below the crowns of the forest at or near the ground surface a remarkable range of variation is found. At one extreme, where sunlight passes through an opening between the crowns, the intensity may be almost 100 per cent of that in the open. At the other extreme, beneath a dense canopy of two or more storeys, the intensity may be reduced to less than 1 per cent of that recorded in the open. This reduction of light intensity penetrating to the ground reduces undesirable weed growth which might otherwise compete with the trees and thus diminish their increment.

INFLUENCE ON WATER RESOURCES

Water war between sky and earth is total and unceasing. Rain batters the soil. Sun and wind retrieve moisture as fast as possible to prepare the next onslaught. Earth guards her surface with a defence in depth and the culmination of this defence is the forest. For it gives a maximum of protection and captures a maximum of water, from which it extracts the fullest energy before release. Luxuriant forest growth indicates a humid climate. Thus forest cover and dependable water supplies are associated in our minds. Just how much this association is a cause and effect relationship is a question that has provoked keen controversy. Some attribute all the desirable qualities of streams which flow from forest lands to climate and geology and deny any effect of the forest itself. Some, on the other hand, are certain that the forest alone is responsible for good water supplies and they plead for widespread tree planting in prairie

and steppe as a means of improving the streamflow. The facts lie somewhere between these extremes.

In any case it is quite safe to say that forest cover may be influential in reducing flood flows: (a) by withholding water from the soil; (b) by regulating the rate of snowmelt; (c) by maintaining or increasing the infiltration capacity; (d) by reducing erosion and thus reducing the bulking of the flood flow by sediment; (e) by maintaining and improving the soil permeability and large pore space; and (f) by bringing about more rapid removal of water from soil storage between storms.

Infiltration. Infiltration can be defined as the flow or movement of water downward through the soil surface. Soils of coarse texture or with fine particles clumped into stable large aggregates have high infiltration rates. The advantages of soil structure are minimized on bare areas because the beating action of raindrops and the sorting action of flowing water break down aggregates and plug pore spaces with fine particles. The litter layer under a forest effectively protects the soil beneath from rain impact and filters out fine particles to prevent the stoppage of the large pore spaces. This layer also furnishes food and protection to useful insects and other animal life which act on the soil and bring about favourable conditions for the entrance of water. Where the forest floor is normally developed infiltration rates are seldom a matter of concern. When the forest floor is disturbed by logging, grazing or fire, protection may be so diminished as to cause surface run-off.

The benefits due to infiltration under forests are the reduction of destructive and wasteful overland flow and the constitution of sufficient ground-water reserves to supply wells and most of the streamflow during dry weather in addition to the water regularly required by terrestrial plants.

Evaporation. Evaporation is the process by which some of the precipitation reaching the earth's surface is returned to the atmosphere as vapour. Experiments show that the evaporation from soil with forest cover is 10 to 80 per cent of that from bare soil. Well stocked or dense forest types have the greatest effect on evaporation. Thus, the forest has a doubly beneficial effect on water conservation: it increases the store by aiding infiltration and reduces losses by preventing evaporation.

Transpiration. Transpiration is the loss of water vapour from plants—mainly from the leaves. The most effective control which a plant has over transpiration is the opening and closing of the stomata, generally attributed to changes in the turgidity of the epidermal guard cells which surround each of the stoma. In areas of heavy rainfall transpiration can rid the soil of excess water and thus decrease the danger of floods.

Interception. Water can be withheld from the soil by interception in the canopy and in the forest floor. The two main effects of this interception of rainfall are to lessen the impact of precipitation from the crowns down to the soil surface, and to diminish the total amount of precipitation infiltrating into the ground. In both these ways forest cover may be a safeguard against the danger of erosion by floods.

Storage and movement of water in forest soil. Water in the soil can move rapidly both parallel to the slope and downward in the large voids. Where underlying soil horizons are dense, root channels may be the principal pathway for water movement. In the silt loam soil of a hardwood forest, Gaiser (1952) found more than 4,000 vertical channels per acre, formed by root decay. The importance of the forest in aiding water penetration into the soil and increasing underground waterflow has often been overlooked. This form of storage is one of the essential functions of forest cover.

Snow accumulation and disappearance. Snow does not affect water yield until melting takes place. Trees influence the accumulation of snow by interception and by reducing wind movement in and below the canopy. Snow melting is thus generally retarded in the forest in proportion to the density of tree cover, whereas in the open the snow melts more rapidly and the additional volume of water released does much to bring about peak floods.

In addition, forests perform a particularly useful function in preventing avalanches. This advantage may be limited to a certain extent in that avalanches often originate on high slopes which are situated above the timber-line. But, even in those cases, forests constitute an efficient protection against avalanches for settlements or other installations on the lower slopes and in the valleys.

SOCIAL CRITERIA

FORESTS AS A SOURCE OF EMPLOYMENT

It has become a substantial part of the policies of many countries to regard forestry and reafforestation also as public works programmes. If they are to be effective, these programmes must fully take into account the indirect influences of the forest, since these may justify the investment even if direct profitability is not assured. In countries where forests have to be restored, reafforestation offers an excellent opportunity to provide transitional employment for workers who may find their ultimate destination in forest industries which do not yet exist. In Greece, for example, the proposed reafforestation programme could absorb several thousands of people, mainly from mountain districts where work is often hard to get. In Spain, the government's forestry programme

employed between 30,000 and 100,000 men, according to the season, in 1956. A bold reafforestation programme for the Eastern Mediterranean would provide employment for some 145,000 to 200,000 men annually over the next 10 to 20 years until the bulk of the new forests have been planted.

FORESTS AS A SOURCE OF RECREATION

It has become a natural and logical development in almost every civilized country to consider forests as an important source of recreation. The concentration of people in crowded cities and large industrial centres makes it more and more necessary to create nature parks and recreation reserves in existing forest areas.

It is a striking fact that a number of countries have never formulated a forest policy or passed a forest law, in spite of evident symptoms of soil deterioration and in spite of repeated warnings about the results of further decline. Governments are sometimes more concerned with passing a trivial piece of legislation than with making effective provisions for the preservation and development of their forest assets. But the warnings that have been uttered should not be overlooked. One of them came from Professor Flatscher some time ago. This scientist at the Academy for Soil Cultivation in Vienna has estimated that the world forests produce about 1,600 million cubic metres of timber a year whereas the volume cut annually amounts to between 2,200 and 2,600 million cubic metres. This indicates that the annual fellings are about 50 per cent above the allowable cut. Any private individual who sanctioned such improvidence would be held responsible for bad management and would certainly be heavily penalized. But mankind as a whole, it seems, can indulge in prodigal waste of this kind without being in conflict with any law. Why this nonsense? The only explanation is perhaps that the inevitable results of violence against the laws of nature seldom fall directly on those who commit the offence.

Though forest areas and timber reserves are still decreasing, there are a few bright spots where we may confidently expect steady progress. The total forested area of the world is estimated to be about 4,000 million hectares and these forests should be capable of providing reasonably adequate supplies of their products for a population larger than now exists. But the provision of such supplies will entail the treatment of all productive forests as renewable crops, the opening up of forests which are not yet accessible, and the cessation of the widespread devastation of forests which, in this twentieth century, still continues.

Of the 1,600 million hectares of the earth's original forest area which man has destroyed, 400 million might well be replanted especially since much of

this land is to be found in places where the population is in greatest need of the products of the forest.

The cost per day of the second world war was a little over $500 million. The cost of one day of this war would reafforest, at least, 8 million hectares, and the cost of 50 days would be sufficient to reclothe the entire 400 million devastated hectares with proper tree cover. Of course, no one is so naïve as to believe that we are on the verge of any such undertaking. But we are in possession of scientific knowledge, industrial skill and technical equipment which could be used to spread the potential benefits of the forest to the uttermost ends of the inhabited earth.

It is up to every forester, politician and even to the man in the street to encourage and promote the creation and conservation of forests, always aware of the words of a great poet: 'You cannot fool nature, it is always true, always serious, always strict, it is always right, and all mistakes and errors are always those of man.'

ARID ZONES AND SOCIAL CHANGES

by
E. W. GOLDING

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The rapid rate of increase in the world's population, together with the undernourishment of half its present inhabitants and the wide difference between the standards of living in the industrialized and so-called underdeveloped areas, has forced world-wide agreement that the improvement of the lot of the less fortunate peoples must be tackled as a most urgent problem. Major efforts, financial and technical, are being made and the recent establishment of the United Nations Special Fund is an important move in this direction.

The terms 'underdeveloped area' and 'arid zone' are by no means synonymous because, of course, aridity is a climatic factor; but the semi-arid and arid zones cover something like one-third of the earth's land surface and must certainly be classed as underdeveloped if we accept as a criterion their relatively small contribution to the general store of wealth in the forms of food and the raw materials of industry and commerce. Climatologists have defined these zones according to the annual total rainfall, and its distribution, to temperature and to other factors, but without entering into technicalities it can be accepted that they are areas in which no regular system of agriculture can be followed without additional supplies of water for irrigation. Water is undoubtedly the key to their development but the quantity required, and the means of providing it, will vary according to the area considered and with the crops which might be grown. It has often been demonstrated that the soil in arid zones is not infertile and that crop cultivation is possible, and even quite successful, with adequate irrigation. Indeed, there is confirmation of this in the covering of green vegetation which often rapidly follows a shower of rain in a dry area where previously nothing at all was to be seen. The writer well remembers travelling along a track, in a dry area in Somaliland, where there had been a shower of rain a day or two earlier. Previous vehicles had followed approximately the same track and their wheels had compacted the loose,

sandy soil. In all the wheel tracks grass had grown to a height of two or three inches and the trail was marked, for miles, by a band of bright green which must have delighted the nomads, continually moving their flocks of sheep and goats in search of pasture.

The distribution of the world's deserts is wide. The largest is the Sahara and the associated zone runs from North Africa, through Arabia and the Middle East and far across Asia into the territories of the Union of Soviet Socialist Republics and China. India and Pakistan have large desert areas but the second largest desert is that which covers the whole of the interior of Australia. South West Africa has the Kalahari desert; perhaps the most arid area in the world lies in Peru, while the south-western part of the United States has also an extensive dry area in Arizona and the adjoining states. Incidentally, a 'by-product' of this aridity in Arizona is the frequent use of the area for making films: the clear skies and desert scenery are ideal for this purpose.

Clearly the problems of development in such different areas are not the same. Some of them are rich in minerals and, while at present useless for agriculture, they contribute valuable raw materials for industry, though exploitation in this way does not constitute general development: it is only a question of highly developed pockets in large wastes of land. In arid zones within advanced countries, such as the United States, the means of improvement could doubtless be found with little difficulty, in the way of finance, if and when it proved necessary. But for the larger part of the dry areas of the world this does not apply.

Water supplies may sometimes be brought in, from distant sources, by pipe-lines, as in the case of the Negev of Israel, or it may be found locally as underground water which may be pumped to the surface if mechanical power, for pumping, can be provided. A second important requirement for development is, therefore, an adequate supply of power.

The problem cannot, however, be solved simply by expending the necessary money to provide water and power. It has often been said that deserts are man-made and this is at least partially true. There is little or no evidence that the climate has changed appreciably during the centuries since some of the desert areas, e.g., in the Middle East and in North West India, were producers of food on a significant scale. Long-continued abuse of these areas, by over-grazing, by the excessive destruction of trees and other moisture-holding and soil-binding vegetation, and the neglect of irrigation systems, has doubtless been a major factor in their deterioration. This is a cumulative process. Land devoid of vegetation allows a very rapid run-off of rain-water and soil erosion takes place on a disastrous scale. The result is that such rainfall as occurs—admittedly little enough—is allowed to run to waste instead of being absorbed to give life to herbage.

Control of the behaviour of the agricultural population, the nomads and peasant farmers, is an obvious necessity but control having the nature of force

is undesirable, even though it be exerted for the general welfare. Education, to enable the inhabitants to understand what is being done and to ensure their co-operation, will undoubtedly provide the best solution.

Social changes are thus inherent in the development of these arid zones, not only as a result of the development but as a very necessary factor in its accomplishment.

THE PRESENT WAY OF LIFE

Existence in very dry areas is governed almost entirely by the climatic conditions which dictate the mode of living. There are some exceptions where, for commercial or, perhaps, strategic reasons, enough capital has been expended to provide water supplies and other services and to allow a reasonably settled life but, in the main, the inhabitants must perforce lead a nomadic life. Settlement, in any permanent sense, is impossible without sufficient water to raise crops on which the inhabitants can live.

H. V. Muhsam writing on 'Sedentarization of the Bedouin in Israel' (Ref. A),[1] emphasizes that the change from nomadism to a settled existence is 'a gradual and slow process; it is concerned mainly with a change in the economic importance of migratory movements in earning the means of subsistence, with the distance covered by the nomads in their migrations, the length of time they remain at a given locality, the attachment to one or several localities to which each family returns periodically, and only in the last place with the construction of a permanent dwelling'.

The details vary from one area to another but the general pattern of life is much the same. The main standby consists of the flocks and herds—of sheep, goats and camels—and these must be almost continually moved to find fresh grazing as they consume all that is to be found in one spot. In spite of the dryness of an area as a whole, there are sporadic rains in scattered places and the skill of the stockherders is shown by their ability to find these places. To do so may entail long treks, with animals becoming weaker as the distance increases. Camels are, of course, very useful animals in such conditions because they can go for many days without water, except when they have been grazing on salt lands. There are known water holes where the animals can be watered at intervals and often these are closely guarded by the tribes in whose areas they lie. Water feuds are common. In some regions, as, for example, in Somaliland, the women and young children are left behind with the sheep and goats while their menfolk and the older boys roam the plains with the camels on whose milk they live, sometimes for months on end. Leo Silberman, writing

1. We may note at this point that a number of important papers on 'Nomads and Nomadism' in arid zones were recently presented in a special issue of the *International Social Science Journal* (Vol. XI, No. 4, 1959), and at the Unesco General Symposium on Arid Zone Problems held in Paris in May 1960. Reference is made throughout the present article to the papers from these two sources, which we shall call 'Reference A' and 'Reference B' respectively.

on 'Somali Nomads' (Ref. A), tells us that 'a woman and three children can exist on 50 sheep and goats and a milking camel, and live lavishly with 100'. The women live in huts consisting of reed mats laid over a framework of bent wooden rods—the roots of a species of acacia. These roots, which spread out from the tree horizontally at a very shallow depth, are cut and then heated and bent to a hoop shape. The huts have no windows. Lighting, if any, is provided by small oil-burning lamps made from a tin can, with a simple wick. But the people rise with the sun and go to bed soon after dusk so that lighting is not very important to them. The huts, which are located near to a (temporary) supply of water and with sufficient grazing for the flocks, are surrounded by a fence of thorn branches. Inside this *zariba* the domestic animals are gathered at night as a protection from marauders, such as hyenas. When a move is essential, the huts are loaded on to the backs of one or two camels, kept for the purpose, and the family walk behind with their stock until more grazing is found.

Some of the people have more permanent homes—mud houses—to which they can return at intervals. These are built near a water supply which can be relied upon and occasionally grain seeds are sown on adjoining land in the hope that, upon the family's return, at the driest part of the year, a crop will have grown. Food consists of grain—usually some kind of millet, boiled and mixed with *ghee* (clarified butter made from ewe's or goat's milk) or with meat. Sheep, goats or, occasionally, camels are eaten when times are sufficiently prosperous. The main meal is cooked at night, little being eaten in the heat of the day. Bread is made by pounding the millet into a meal which is moistened and allowed to stand overnight so that some fermentation, which serves the purpose of yeast, can take place before the dough is baked next morning. The millet is obtained by the non-cultivating stockherders in exchange for animals or the skins of animals, or, perhaps, in exchange for charcoal made by burning down yet another of the much needed, shade-producing trees. For cooking and for night fires—for it is often cold in the desert at night—more wood is needed. Other trees are destroyed by the practice of 'lopping', branches which are too high for the animals to browse upon being partly cut through so that they bend down to ground level: these branches, if not the whole tree, eventually die.

Apart from this obvious wastage of valuable vegetation, there are other forms of waste brought about by the nomadic existence. Thus, for example, the female camels give more milk than can be consumed by the menfolk when on the move and the considerable surplus is wasted. The valuable skins of the sheep and goats—particularly the former—cannot be properly cured and thus lose much of their value as export products.

Nomadism certainly has the advantage of being an independent mode of life. The nomad finds all that is necessary to support himself and his family —so long as the rains do not fail. But if they fail his state is precarious in the

extreme. The long treks in search of grazing, covering scores of miles from his home watering place, may leave him too far from his base to allow him to return without considerable loss of life, through weakness, among his animals and his family. Thousands of people in Somaliland have, in the past, been saved from death in this way only by government-organized relief camps. With regard to animal losses, Vincent Monteil, writing on 'The Evolution and Settling of the Nomads of the Sahara' (Ref. A), tells us that 'in February 1954, in the Djelfa area, 700,000 animals died of starvation and cold'.

It has been possible, in some dry areas, to construct artificial pools to retain water for some months and to permit cultivation of the surrounding land through irrigation. But, here again, there is a difficulty in that the (normally dry) rivers which occasionally feed these pools do not always take the same course. Because of erosion, the water course that brings the rain-water down from the hills is not always very definite so that the next spate may take an appreciably different course from that which fed the pool, thus leaving the cultivated area literally 'high and dry'. Whatever encouragement is given, by governments, to further settled cultivation, the fact has to be faced that the nomad is not traditionally a cultivator. His ancestors have roamed the deserts for centuries and he tends to be suspicious, or doubtful, about settlement—with some justification. The tendency is, therefore, for him to accept a piece of land ostensibly to cultivate it but, in fact, to use it as a private reserve in case the grazing fails elsewhere. And, further, he may have little taste for the crops which can be grown on such land because he is used to a simple diet of millet and meat.

Nevertheless, there are many signs that settlement can be brought about. A. S. Helaissi, writing on 'The Bedouins and Tribal Life in Saudi Arabia' (Ref. A), mentions the artesian bores made by the Ministry of Agriculture to supply drinking water for the desert Bedouins and says that 'The Bedouins are already beginning to appreciate the importance of these wells and, despite the heavy expenses involved, they have started to drill their own wells to provide water for irrigation'. He does however bring out the point that it is difficult for a nomad to conceive of the notion of a 'home' and to understand that such a home will offer him protection and provide him with a living. In this connexion H. V. Muhsam (Ref. A) suggests that the first step is to persuade the nomad to acquire an interest in, and attachment to, a piece of land by sowing a perennial crop, such as sown pasture, or by planting fruit trees.

It is probable that some dry areas could best be used economically through a mixed form of agriculture with both stock-herding and cultivation in balanced proportions. The number of stock should, however, be regulated in accordance with the carrying capacity of the area. Too often there is over-grazing because the need for some kind of insurance against bad times encourages the rearing of an excessive number of animals. But it has to be remembered that a camel,

for example, which eats 15 to 20 tons of fodder a year, may prove an expensive form of insurance.

While life in Somaliland, which is semi-arid, rather than extremely arid, has been taken as an example of the mode of existence of nomadic peoples, conditions there are probably fairly typical of those in many other areas as well. In general the life is primitive in the extreme—centuries out-of-date by European standards.

There can be no doubt that many of the inhabitants of desert lands have a superb knowledge of the characteristics and potentialities of their environment: they must have such knowledge to survive. And this is allied to a sturdy independence which is, after all, a quality not to be despised. Understandably, perhaps, these people live only in the present: the future will take care of itself, or so they hope if they think about it at all. If one's animals are starving it is only natural to seek all possible means of preserving them, even if these means endanger future supplies of food. But this cannot excuse the wanton damage which is often done to young trees which have been planted by governmental and development authorities to provide shade and encourage further vegetation. Unless great care is taken in guarding these plantations, herds of goats, guided by their owners, will quickly eat off the young growing shoots of the trees and ruin them. There have indeed been instances of apparently purposeless destruction of more mature trees and it is common practice, in the Somaliland Protectorate, to make charcoal by cutting down, and burning, a growing tree even though there are dozens of dead trees in the vicinity. This still happens in spite of fines being imposed with the object of stopping the practice.

Intelligence is not lacking in many nomadic peoples and they have often shown how easily they can adapt themselves to the ways of more advanced countries. Many who have taken service with European families or commercial concerns have become excellent house-boys, cooks, chauffeurs, etc. The inhabitants of some areas make good mechanics and display considerable ingenuity in improvization when faced with emergency breakdowns of machinery. Discussing the possibility of improving desert agriculture by the use of machines, Muhsam (Ref. A) says: 'In Israel the Bedouin exhibit more understanding for, and ability in, the use of the tractor, the combine and other agricultural machinery than large sections of the fellaheen. One of the reasons is the high intelligence of the Bedouin and their flexibility of mind. Furthermore, the use of agricultural machines does not carry the stigma of traditional agricultural labour: the driver of the tractor is as free a man as the man of the desert who rides on camel back; in fact, under the conditions of the Negev, the automobile is often an even more convenient and noble means of transportation than the camel and is gladly acquired by many of the well-to-do Bedouin of Israel. And, in any event, in the eyes of the Bedouin, there is no difference in principle between driving a car and driving a tractor.'

Such accomplishments are not negligible but the real problem is to bring

some elementary education to the majority of the people—the nomads and the peasant farmers. Often there is not even a written form of their language: it is only spoken, and even when there is a written form it is extremely unlikely that the literature will contain anything which could help in teaching them what is needed for their own betterment.

Health is another important question to be tackled. In the past it has been largely a matter of the survival of the fittest and, through generations, certain immunities to disease have doubtless been built up. To take but one instance, the water found in desert wells is frequently so saline and impregnated with other impurities that anyone unaccustomed to it would rapidly sicken but the local inhabitants appear to thrive on it. The writer remembers visiting a small village hospital, run by a native trained to treat simple ailments. The water in the village well was very strongly impregnated with sodium sulphate (Epsom salts) yet most of the 90 cases which had been treated within the last three months had been people suffering from constipation. It was not certain, however, that all of these cases were from the same village.

In spite of the apparent fitness of many of the adults, the children are often seen to be suffering from diseases, and running sores, covered with flies, are a common sight. Health services have been instituted to serve some arid areas but much prejudice must be overcome before the people will allow themselves to be treated. There have, however, been instances of success in this and, in the Negev, in Israel, Bedouin women have actually been persuaded by the Israeli medical authorities to attend a child-welfare clinic.

The almost complete absence of a money economy is another cause of difficulty. Leo Silberman, discussing the establishment of the new Somali State (Ref. A), says 'if a new State is to be built quickly more people must be diverted from the "camel economy" into a money economy'. Such trade as exists is conducted mainly by bartering. Animals or skins are exchanged for grain, coffee or, perhaps, cloth or simple utensils. Money does not enter into the bargain and consequently the people have no capital reserves in monetary form. The result is that, when bad times come, during seasons when the rains fail, the only possibility is to attempt to dispose of the animals which by that time are near death from starvation. There is, however, the argument that money is useless if there is, normally, nothing that one wants to buy or, alternatively, there is nowhere to buy it.

This leads to another question, that of road communications and the possibilities of opening up inland areas to trade. In general, roads are either very bad or non-existent in arid areas. The 'trade trucks' (travelling shops) which occasionally brave the bad conditions often founder in loose sand or even, in semi-arid areas where sudden torrential rains fall, in deep mud. More and better roads are essential but these will be costly to build and, unless they can be given some protection from blowing sand or from uncontrolled floods when the occasional storms occur, will be equally costly to maintain. The trade

trucks are probably the only solution to the problem of trading up-country until some degree of settlement can be attained. Village shops may then appear in greater numbers than at present.

The conception of development to bring about some of these very necessary changes presupposes that either the government of the country responsible for the dry area, or some international agency, will be able to provide the capital and technical effort required. Conditions in different arid areas vary so widely, in the political sense, that it would be unrealistic to attempt to specify any single mode of procedure. One point, however, is clear—the inhabitants of the area to be developed must co-operate in the development. They must agree to accept the changes, being persuaded that they are truly beneficial, and thereafter they must be placed in a position to take advantage of the better facilities made available. Initial construction and organization will have to be followed by self-help on the part of the inhabitants who may need technical training to operate some of the new installations. Above all, there must be a sense of responsibility so that all who share in the improvements are fully aware of the fact that their continued success depends upon collaboration. In some areas, such as the colonial territories now seeking independence, it is difficult to foresee who will be able to take effective responsibility. It is easy to understand why this is so. People who, for centuries, have pursued their own course quite independently of their fellows—even in violent competition with them and certainly not collaborating except in a limited, family, sense—cannot easily grasp the implications of development on a regional scale. They have had no opportunity to meet and discuss matters of common interest except in the event of dire emergency. Yet now they must suddenly be called upon to form district committees, councils, perhaps parliaments, and to choose leaders who will study the common weal rather than their own self interest. This aspect of the question of development is, indeed, of prime importance and needs the utmost care in handling. The present method of forming legislative councils, with native members as well as Europeans, is undoubtedly a step in the right direction.

THE WAY OF LIFE AFTER DEVELOPMENT

To jump from the present primitive way of life to consider that which will follow a comprehensive programme of development is to omit a very important intervening period to which we should first give some thought. With the best of good will between the advanced nations and those responsible for the underdeveloped arid zones, and with all the financial and technical aid which could be imagined as feasible, it would be too optimistic to expect that there could be, in general, any rapid transition from one form of existence to another, quite different, one.

Clearly, the changes must come about gradually in most areas. There may

be exceptions when a selected group of people undertake—as they have done in the *kibbutzim* (agricultural co-operative settlements) in Israel—the establishment and operation of a sizeable agricultural holding in a dry area. But, in the main, when it is a question of persuading a nomadic population, in which habits and customs have been engrained through centuries of experience by their ancestors, to adopt a new way of life, only a step-by-step process is foreseeable.

Lines of development, within this process, must, however, be followed in parallel. The education which alone can offer the full solution to the problem of bringing about the necessary changes with co-operation from the inhabitants is, of course, essential but its fulfilment will be slow. In the meantime something must be done, even though full advantage of the schemes introduced may not at first be taken.

One can envisage the establishment of wells at conveniently situated places, the water being pumped by simple windmills and stored—perhaps in covered, semi-underground pools to reduce evaporation—for the benefit of the nomads who would be able to water their stock freely there. There may be difficulties in locating these installations but underground potable water can often be found at no great depth and the plan would appear to be feasible.

Demonstration gardens, or small agricultural holdings, might be established to show what could be done if the best methods were followed. Pioneering settlements, of selected groups who may be willing to undertake to run them, could be initiated as an example to others.

One method which has met with some success where settled agriculture has been started has been to organize simple 'agricultural shows' with prizes for the best crops, animals or farming methods. Wherever the necessary raw materials are available, small rural industries, e.g., weaving or basket-making, could be established.

All these methods of encouraging settlement and improvement of living standards will call for leadership as well as intelligent organization by the authorities. It is not, perhaps, too much to expect that such leaders could be found if the right techniques were used in encouraging them at the outset. The method to be followed would be full support and the provision of certain basic equipment after which self-help would be the rule though assistance through advice, and though the organization of a marketing scheme when there may be surplus products, should be made available.

In spite of the fairly general conviction that settlement is the most effective method of improving living conditions in arid areas, it should be noted there are various points of view to be considered. Thus, Frederik Barth, in a paper on 'Nomadism in the Mountain and Plateau Areas of South-West Asia' (Ref. B), gives a warning against the complete elimination of nomadism: 'such wholesale sedentarization has proved difficult to achieve and, in cases where it has been strongly enforced, it has often had disastrous results, causing

high mortality of stock and people, pauperization and proletarization of large populations, and economic decline in whole provinces. Furthermore, no alternative patterns for the utilization of grazing resources have emerged.... Pastoral nomadism in South-West Asia is a specialized occupation pursued by a discrete segment of the population, usually ethnically distinct from the sedentary population of the same area'. He suggests that 'the possibilities of *modification and adaptation* of nomadic forms to present conditions have not been sufficiently considered' as an alternative to sedentarization.

An interesting, and very important, problem is raised by the present lack of an economy based on money. The nomad, unaccustomed to the things which more advanced peoples think essential—it may be radio sets, refrigerators, fans or even bicycles—is not, therefore, urged to accumulate money with which to buy them. One step in the transition from the barter system may thus be the inculcation of a desire for the 'gewgaws' of modern life. The argument runs thus: if a man wants a radio set he must have money to buy it: he must, therefore, sell some of his products for money instead of bartering them (unless the radio salesman happens to want a camel!). By establishing the idea that money can be exchanged for useful commodities one makes a start on the limitation of numbers of animals as representing wealth: wealth in animal form is extremely vulnerable in times of exceptional drought.

It is, indeed, a strange thought that one may need to encourage a wandering Arab to want a radio set—or some other gadget—in order to make a start on a new system of economy for his ultimate good. Are we justified in trying to change the mode of life of an independent people in this way? Perhaps we should not be justified if such people were likely to remain happy, healthy and contented with their present existence, but it is not realistic to expect that they will remain so in the face of the much better living standards with which they must inevitably make contact when they occasionally visit the towns.

The choice to be made is, basically, between a low standard of living with intermittent prospects of starvation, but with complete independence, and a better standard, with a reasonable degree of security, but which will involve some loss of independence and conformity with certain social codes of behaviour. If we, in the more advanced countries, are appointing ourselves as advisers, benefactors, or whatever title we care to adopt, we must realize clearly the implications of our schemes upon the recipients of our assistance. We have to find ways to inform peoples who are ignorant of many of the possibilities in modern life of what they *could* have, for they cannot ask for something which they do not even know exists. But it would be taking advantage of their ignorance if we did not, at the same time, consider carefully whether all the possible new introductions are likely to be truly beneficial. Sometimes, of course, new ways of life may be introduced by exceptional conditions, e.g., those which existed in the Western Desert of Egypt during World War II. A. M. Abou-Zeid, writing on 'The Sedentarization of Nomads in the Western

Desert of Egypt' (Ref. A), points out that: 'Men who were employed as unskilled labourers during the war by the different combating armies became accustomed to paid jobs and to cash remuneration, which had previously been practically unknown to them. When the war ended it was not easy for those workers to go back to the old nomadic life with all its hardships and insecurity.' Such exceptional cases, however, do not alter the situation in general.

Let us go on to suppose that the first stages have been passed through and that true progress has been made in the development of an arid area. The most obvious change that we are likely to find is that communities have arisen wherever dependable supplies of water have been made available. To dwellers in temperate climates, where water is not usually a problem, the extent to which life in an arid region depends upon water and the bitter struggles that are often brought about by competition for the little water available are perhaps difficult to imagine. Egypt is, of course, the classic example of this dependence on a large scale. The only fruitful and inhabited parts of the country, apart from the coastal strips and two or three oases, are along the banks of the Nile—without its water the country could not exist.

Communities can be organized so that there is a corporate form of life with at least simple forms of public services. The writer has visited a number of such communities in dry areas. Several of these were in the Negev of Israel. One was Tel Yerucham in the Northern Negev. Here there were some twenty or thirty small wooden houses housing as many families who were employed in the quartzite and kaolin mines a few miles away. The workers were taken daily by motor lorries to their work. The village was surrounded by desert but there was a supply of water adequate for the needs of the small population. Each house had electric light from a 15-kilowatt diesel-electric set which also supplied some public lighting in the centre of the village and in a 'village hall' where meetings could be held. It was perhaps a poor place in which to live but the houses were well kept with verandas and (very tiny) flower gardens. Some people kept poultry to eat up their scraps. But the most interesting feature was certainly the sense of community spirit which even the very limited 'public services' of electric light and a communal meeting place had engendered.

Not many miles away, and still in the dry desert area, was a *kibbutz*, an agricultural settlement to which a water supply had been taken from further to the north of Israel. Here there was agriculture in the commonly understood sense of the word. With irrigation it was possible to raise crops and even to keep cattle: part of the diet of the cows consisted of water melons or gourds. In the *kibbutzim* there is a highly developed community sense. All the members work on a completely communal basis, without pay except for a nominal allowance. The women run the kitchens and dining-room where all take their meals under clean and thoroughly hygienic conditions. Each family has a tiny house but the children of school age live together in a 'boarding school'

within the *kibbutz*. The infants are cared for in nurseries while their mothers work. Even the children, in out-of-school hours, have their tasks to do about the farm. Often some light industry is incorporated so that, by exporting manufactured articles, purchases of essential goods from outside can be financed. There is a weekly meeting of all the members who then decide the policy to be followed in the work and settle any difficulties. A republic in miniature.

In the same area of the Negev there was another settlement of quite a different kind, the existence of which has a direct bearing on the question of establishing some sort of settlement by nomads. This consisted of a number—perhaps 20 or 30—of Bedouin tents clustered round a reservoir which the Government of Israel had built. These families, with their animals, had been attracted by the water and had made this their base from which they could radiate, with their animals, in search of grazing. They had not yet attempted any individual cultivations although some of them worked on the land of a sheikh not far away. This sort of settlement can be looked upon as the beginning of the formation of a community, the more advanced stage of which is represented by the *kibbutz* already mentioned. An early result was that it became possible for the health authorities to make contact with these hitherto nomadic people and to treat several cases urgently in need of help.

Yet another kind of settlement in a very dry area, much larger and organized on a more ambitious scale, is that at Abyan, in the Aden Protectorate. For decades before World War II, the Abyan plain, which had once been irrigated and productive, had been allowed, through tribal feuds, to become completely neglected and derelict. Only very few poor and scattered huts existed. Wartime needs for food forced the organization of a cultivation scheme by the government. A committee was established to run the scheme and the old irrigation canals were put in order. Grants of land were made and water, to be paid for by surrendering a fraction of the crop grown, was provided whenever the rainfall on the distant hills (the actual rainfall at Abyan itself is almost zero) caused a flow in the normally dry river bed; sluices were operated to give each farmer, in turn, his fair share of water. Millet, vegetables and, later, cotton, were grown. The farmers sell to the organizing authority, the Abyan Board, and the scheme has been sufficiently successful for about 100,000 acres of land to be reclaimed. Where, but a few years ago, there were those few huts there is now a flourishing community of several hundred families, with a market, public services, shops and other features of civilized existence.

In Sinai the Egyptian Government has encouraged the formation of co-operative societies, some of which consist of as few as ten people, earnestly wishing to develop a plot of ground for agriculture. These societies are registered and can make requests for governmental assistance—particularly for the sinking of wells of which 40 have already been sunk in districts where the hydrological service has been able to agree that such wells will not be detrimental to others in the same area. Repayment by the societies of the initial expenditure is on

hire-purchase terms over a long period of years. The individual farmers are not bound to market their crops through the co-operative society which has, however, good marketing facilities and can usually offer a better price than the farmer could obtain by a private sale. The Egyptian societies are thus government-assisted but are not government-controlled and the system is working well.

Yet another settlement, in an extremely arid district of Israel, was at Eilat on the southernmost tip of the Negev and on the shore of the Gulf of Aqaba. Here the Israelis wished to establish a settlement to be developed, in time, into a seaport. In addition to a military station and an air strip on the sea-shore, some small houses had been built to house such inhabitants as could be persuaded to live in this hot, dry and apparently barren place. To provide some amenities and, at the same time, to test the possibilities of various kinds of trees and shrubs in withstanding irrigation with the saline water available for such purposes, the government's botanical department planted a park. To give the inhabitants something profitable to do—because agriculture could not be envisaged, at least in the earlier stages of the settlement—a local industry, based on the very beautiful shells found in the waters of the Gulf of Aden, was started. Many kinds of ornaments were being made and great ingenuity was displayed in devising new uses for the many kinds of shells found. The next step, though a major undertaking of great cost, was the construction of a road which would connect this distant, potential seaport of Eilat with the northern part of Israel so that, eventually, trade could take place on a significant scale.

We see in all these developments encouragement for the future and, at the same time, lessons to be learned. We learn that the settlement of nomads can, indeed, be achieved; that a community spirit can be attained in an isolated desert settlement; that people unaccustomed to organized existence will respond to organization if they are given the essentials for improved living standards and the assurance of some security; that groups of people are willing to live in, and to develop, apparently very unpromising districts if they can be given that initial assistance without which existence in such places could not be entertained. There is much truth in the saying that man will live wherever it is possible to live. But they must be helped through capital expenditure at the outset and there must be some obvious method of making a living to enable them to repay—perhaps over a long period—the money furnished to give them a start.

These few examples are all within the writer's own experience: no doubt others who have travelled in arid areas could give many other examples but these will perhaps suffice to show that a change in the way of life of the desert's inhabitants can be brought about by fairly simple means.

What are likely to be the main changes to be observed when community life replaces nomadism or when a group of hitherto independent people are brought together for the development of an area of land in an arid zone?

In the first place the housing can be of a permanent form instead of consisting of movable huts or tents. These houses may be small bungalow-type dwellings made of wood or metal—an aluminium outer skin can be used to reflect the sunlight and to maintain reasonably cool conditions within. They may be made of mud and wattle having a timber framework with reed matting attached to it and then coated with mud. Or they may be built of mud bricks which can be made fairly easily in a hot climate when there is sufficient water, and suitable soil, to mould bricks that can be baked naturally in the sun. Although such houses are small and, by European standards, crude they are by no means uncomfortable to live in and are a great improvement upon the tents or movable huts.

Once the houses are built, some form of sanitation, though simple, can—and, in fact, must—be introduced to avoid the unpleasant and unhygienic results of a more concentrated mode of living. Health authorities responsible for a region in which such communities have been established can encourage cleanliness and can treat cases of disease before these have a chance to advance too far or to spread to other people. Local hospitals, serving districts, can be established. This may sound too ambitious but it is truly surprising to see how much can be done in even a two- or three-roomed, mud-walled building which is kept clean and equipped with one or two beds and a few simple medicines and medical stores. These local hospitals can be placed in charge of natives of the country concerned after training for such work. It is possible to envisage also the use of small aircraft to transport more serious cases from these local hospitals to the main towns where they can receive treatment by fully qualified doctors.

In time, as development progresses, even if it does not form part of the initial establishment, a power plant of some kind—driven by diesel engine, windmill, a small steam engine or, perhaps, by solar radiation—will be installed. This can be used to pump water for a public water supply in the form of hydrants for communal use, and to provide electric lighting. These two services, in themselves, have an immediate effect upon the general standard of living. Cleanliness is made possible and the people need not be governed entirely by the hours of daylight in planning their work or their leisure time. Public gatherings in the evening become possible and people need not be afraid to walk about at night in a village that has even an elementary system of public lighting. This is an advantage which should not be dismissed as being of little importance. The writer has stayed in African villages where it was essential to carry a lamp when moving outdoors at night because of the deadly snakes which sometimes lay about on the pathways.

Education, which is a vital necessity from every point of view, can be undertaken through the establishment of district schools for the children and perhaps by visiting teachers to address gatherings of the older people. According to Helaissi (Ref. A), even mobile schools, which accompany the nomads on their

migrations, have been adopted successfully in Saudi Arabia. Radio sets become possible when there is an electricity supply and even one of these in a community hall, by transmitting information through the spoken word instead of relying upon the literacy of the inhabitants, could be of great benefit as an educational factor.

These amenities cannot, of course, be provided without cost so that, if the inhabitants are not to be continually subsidized, they must pay for them. Clearly the system of barter has serious limitations as a medium of exchange and an appreciation of the value of money must be developed. Surplus products of agriculture or of rural industries must be sold for money. Shops may be established to replace, or to supplement, the 'trade trucks' and, when sufficient confidence has been built up in the minds of the people, banks may begin to function.

Roads can be built to serve communities and, although these may not be of very high grade, they are capable of opening up communications with the more important towns.

Soon, in any kind of settlement, the need for leadership and organization will be felt. Someone, or some group of people, must take decisions for the common good and must ensure that the inhabitants obey rules of conduct enabling life to proceed reasonably smoothly. A political sense is thus acquired even though it be in a very elementary form.

But, in all this, there must be some over-riding control of the population to avoid the 'drift from the land' which is a common tendency in agricultural areas in many parts of the world. Development of land for agriculture needs people to work on the land not to congregate on the outskirts of the towns attracted by the amenities there. There is nothing more depressing than the sight of a conglomeration of filthy shacks, made of oil drums, broken boxes or any other junk that can conceivably be put together as a shelter from the weather, clustered round a town where the miserable dwellers in them hope to scratch a living. Instead of the independence of the nomadic peoples one finds here people who are largely demoralized, ill-fed and ill-clothed because the town offers little employment for which they are suited. This is, of course, no new problem: it is present in the industrialized countries as well as in arid zones but the provision of amenities and the possibilities for a decent living in the rural areas is the only foreseeable answer to it.

THE INFLUENCE OF AN IMPROVED STANDARD OF LIVING

So much depends on the background against which improved living standards must be viewed, upon the race, religion, history and traditions of the peoples concerned, that it would be impossible to formulate any general rules or to specify precise effects which would be found universally. Nevertheless, it is worth while to consider what might be expected in different circumstances.

First let us think of the influence of better housing, with adequate lighting and sanitation. How will peoples who have been accustomed for centuries to exist under the most primitive conditions react to such accommodation? Poverty, dirt, disease and squalor must eventually demoralize but does this demoralization become inherent or can it be overcome in a reasonably short time by improved conditions? The change will certainly take time and will most probably be brought about through the children. If they can be taught in clean and well-kept schools there would seem to be a good chance of the lessons of hygiene bearing fruit and bringing about gradual changes in the home. A. S. Helaissi (Ref. A) writes, of the influence of development, 'If, in the past, environment has had a powerful influence on the Bedouin and has been at the very source of his inherited tradition, it will not be surprising if today a new environment, which includes education, medical care and agricultural assistance, has an even greater effect in creating new traditions for him.'

The writer was once most impressed by an experience in a country district in Haiti. He visited a poor little house, with an earth floor and mud and wattle walls, thatched with dried leaves. It had only the most rudimentary amenities but there was certainly a lamp. During his conversation with the (quite illiterate) old lady who lived there, her grandson, a boy of perhaps nine or ten, came home from school with his satchel and school books with which to do his homework. The old lady was obviously very proud to have this little scholar in the house and, no doubt, would do her best to enable him to take advantage of his schooling.

There is no good reason for thinking that the response to better living conditions will not be good, though, at first, there may be some lapses like those found at one time on a new housing estate in England when some of the inhabitants, moved there from a city slum area, found their new bathrooms good places in which to keep the coal or, sometimes, pet rabbits.

With adequate lighting and comfortable conditions within the houses, evening studies, or profitable activities such as weaving, mat-making or embroidery, will become possible for those who are so inclined. No doubt there will remain many who are unable, through lack of intelligence, or unwilling, to improve themselves when given the opportunity. These will continue as illiterate peasants but there is clearly a possibility for a 'middle class' to arise and this has, in the past, been largely absent in arid areas. There has been a general tendency for only two classes to exist—the landowners or chiefs, and the peasants. It is this new middle class, which has had the initiative and strength of mind to raise itself from the lower stratum, which will be the best hope for the future in these countries. People who know the hardships of life under primitive conditions, yet have learned to appreciate the possibilities of development, are the most likely to provide, from among their numbers, the leaders, the administrators and politicians who are so much needed to steer developing areas along the right courses.

Better nourishment is another factor which will influence thought and behaviour. It is generally accepted and, in fact, statistics for increases in population and for the average daily intake of calories prove that the under-nourished peoples breed much faster than those who are better fed. It is an ironical situation that where there is not enough food for the present inhabitants the number of extra mouths to feed increases most rapidly. It is, however, true that in some underdeveloped areas the death rate among young children is so high that this has been a curb on the increase in total numbers. Health services, which will form part of the improved standard of life in the arid zones, should certainly reduce this death rate and it is a moot point whether the better food and better living conditions, tending to bring about a reduction in the birth rate, will be counterbalanced by the lower number of deaths among the young children. In several of the countries concerned, birth-control practices are already being taught through official organizations and it must be hoped that these efforts will be successful.

This question of improving nourishment can be somewhat complicated by long-established customs or by religion. Thus, nomadic stockherders almost inevitably become largely meat-eaters although this diet is supplemented to some extent by millet, rice and other grains. Water supplies, in sufficient quantity for irrigation at newly established agricultural settlements, may lead to the raising of crops which are well suited to the climatic and soil conditions but to which the inhabitants have not been accustomed. Good, fresh food in the form of vegetables and fruits will become available. The next need will be to persuade the inhabitants to eat it.

Experimental work, in the United States, Japan and other countries, has shown that it is possible to raise algae—uni-cellular plants which grow in water and which make especially good use of solar radiation for photosynthesis—in hot climates. The amount of water needed is relatively small because it can be used repeatedly, the culture being in tanks from which the algae are harvested at frequent intervals. The result is a foodstuff with a high protein content very suitable for animals. The animals may not be so particular as their owners when presented with a new kind of food but the technique of raising stock on local factory-made food, instead of on natural fodder sought by roaming the deserts to find occasional patches of greenstuff, is something which would have to be taught.

Religious questions enter into the matter because of adherents being forbidden to eat, or drink, certain foods. Pigs or cows may not be eaten in some areas: alcohol may be forbidden. The religious laws were made centuries ago and were doubtless wise, for their day. In hot climates, especially with animals subject to tropical diseases, some fresh meat was not good and the laws against its being eaten were probably dictated by considerations of the people's health. Alcoholic drinks were not wise for the nomadic, and often hot-tempered, peoples. One should not discount these laws laid down by the wise founders

of the religions adopted in hot countries but, nevertheless, the reasons for their formulation may not apply with the same force today when both animal husbandry and social codes are so different. It may be, for example, that pigs would thrive in the kind of agricultural settlement which may result from development of an arid area or that grapes would be the ideal crop for a dry hillside with a limited water supply.

Clearly it is no part of the work of a development authority to attempt to interfere in religious matters. It may, however, be faced with the choice between granting agricultural holdings to people who can take advantage of the produce and initiating an export trade so that, although the raisers of the produce do not themselves use it, an exchange is effected with an area which can provide acceptable goods in return.

Marketing schemes will probably be needed to organize the effective use of surplus products produced by communities. Some of these communities may, indeed, specialize on certain agricultural crops particularly suited to their own areas and conditions. Some may be fruit growers, others vegetable growers or, perhaps, stock rearers or poultry keepers. And with this specialization it is certain that a much improved form of agriculture will arise: experience is concentrated on one crop and its special needs in cultivation, in fertilizers or in the prevention of diseases can be studied with the guidance of national agricultural advisory services.

Perhaps the most significant of all the effects of a changed form of life in which communities replace scattered units will be the creation of a sense of responsibility in considering others. Instead of merely the family there will be the village to consider. One's neighbours will no longer be rivals secretly trying to obtain the best grazing in sparse pastures or to be first to reach a water supply before it goes dry. All will be working together to maintain the facilities that the village offers. Individual independence will be replaced rather by group independence with the needs of the community considered as well as those of the family. Social consciousness is bred in this way and the next step is obviously a realization of the importance of political questions. Leaders and some kind of 'parish council' must be set up to keep the community's affairs in order and to make rules. This involves the choice of persons to act in these capacities and elections are the next step in the process. Thus, given the means of establishing and maintaining a community, it is but a short step from nomadism to a self-governing group and an electoral unit capable of sending a representative to a national assembly.

The responsibility of the appropriate authorities to bring about such changes as those mentioned seems clear and we can agree wholeheartedly with Vincent Monteil (Ref: Unesco/NS/13/524, p. 2) who quotes Théodore Monod to emphasize the point that the nomads deserve 'the intelligent care of those whose object it is to improve man's living conditions and to bring about the changes that are needed'. To this however Monod adds the proviso: '. . .

while at the same time respecting the rich variety to be found in the behaviour, psychology and ways of life of mankind, which means that there are irreplaceable types of mankind who are quite different from us, and who have the right—perhaps even the duty—to remain so'.

In considering the effects of measures to improve the economy and standard of living of nomadic populations, we must not overlook the broader social aspects of the question. Thus, Mohammed Awad, in his paper on 'Nomadism in the Arab Lands of the Middle East' (Ref: Unesco/NS/13/524, p. 14), concludes: 'It seems desirable that the economic integration of tribes through sedentarization should be followed by their social integration with the rest of the population. But, however desirable such a result may be, it should never be forced but should be left to the more gradual evolution of society and social institutions, through education, in all its different aspects. This process might take several generations and its pace should be left to circumstances. It is generally felt that the tribal spirit should not be destroyed but allowed to merge gradually into the national spirit, through the usual co-operative activities of the modern State.'

THE IMPLICATIONS OF THE FINANCING OF MAJOR DEVELOPMENTS

While many small schemes of the kind already instanced are possible within the economy of a number of countries with underdeveloped arid or semi-arid areas, these can be regarded only as beginnings. They are certainly important and, as their number grows, will make a major contribution to progress in the areas concerned. Indeed, small settlements will continue to form part of new development no matter how great its total magnitude. But we should consider also the question of the major, national or regional, developments which may sometimes be financed from the funds of the country responsible or, more often, are made possible only by the provision of large capital resources from international organizations such as the World Bank. These are commonly hydro-power schemes, irrigation schemes or, perhaps, a combination of the two. In future, under the United Nations Special Fund and with increased funds becoming available to the World Bank, projects of this kind will increase both in number and in scope and we should no longer be deterred from considering developments which would benefit large populations merely on the grounds that they would entail very heavy expenditure. For most of the schemes which can be shown to have a good chance of success in improving the lot of large numbers of people support is likely to be forthcoming—not, of course, immediately, but in the course of the next few years.

Even so, the very large sums of money required have to be furnished from public funds in the countries which can provide them and it is essential that great care should be taken to ensure, first, that the money is not wasted on the constructional work itself and, second, that the peoples benefiting from the

schemes shall not find repayment of the capital an intolerable burden. One criterion of the worthwhile nature of any scheme should be whether it is likely to become self-supporting in a reasonable length of time. Power from a hydro-electric scheme, or water from an irrigation scheme can be sold and, although it may be necessary to allow generous terms for the initial period, eventually the project should be commercially successful.

For these reasons great care is taken in investigating projects submitted by would-be borrowers, to make certain that the money will be well spent and that an adequate financial return will be possible. Development schemes of this kind are almost always fixed in locality. For example, the object of a scheme might be to harness the uncontrolled waters of a river system, thus preventing disastrous floods and providing regulated irrigation for a considerable area. Another might be a purely hydroelectric scheme. In either case a good deal of organization will be necessary in the area concerned. Irrigation cannot be allowed to take place in any haphazard fashion. The land to be irrigated—assuming that it is not already occupied and cultivated—must be divided equitably between people who are capable of cultivating it and who are prepared to pay, in money or in kind, for the water which they receive. There can be, of course, much flexibility in the method of dealing with the matter. It may well be that, beyond the main scheme itself, there should be an auxiliary one to provide agricultural implements and stock and housing accommodation for the farming communities to be established. Until the project gets under way and the cultivators are able to support themselves and their families, little payment can be expected but, as time goes on, their increasing prosperity should enable them to contribute appropriately.

A problem which frequently arises with a hydroelectric scheme stems from its distance from centres of population. If large distances have to be covered by high-voltage transmission the cost of the energy—which may be very cheap at the power station itself—is considerably increased. It is important, therefore, to consider whether any use can be made of this energy near to its source. There may be mineral deposits or other natural resources in the adjacent area which could be worked and treated locally. It may be worth while importing raw materials for the establishment of a new industry but the question then to be decided is whether the transport of these materials, and the subsequent return of the finished products, will cost less than transmitting the electrical energy to the source of the raw material.

Thus the irrigation schemes create more prosperous agricultural areas while hydroelectric schemes tend towards the establishment of industries, particularly because the power generated is usually far too great to be used to the fullest advantage in an agricultural area. The combination of the two sorts of development is, in fact, very desirable because they are complementary. The industrial area provides an outlet for agricultural products while the industrial production can be exported to finance imports.

In areas where developments of this kind are taking place, or will be started soon, it is sure that we shall see major changes in the social, economic and political life of the people. There will be a revolution in thought as well as in living standards. But by no means all the arid zones have the possibility of receiving aid in this way because of the simple fact that the prime essential of a large, controllable flow of water does not exist. For them the hope must be that a large number of small projects, for water pumping at wells, for purification of saline waters and the like, can be financed or that, in the not-too-distant future, more easily transported forms of energy—perhaps small nuclear plants—will become available at sufficiently low cost.

Financial assistance for major developments must be matched by assistance on the technical side. Whether it be an irrigation scheme or a hydroelectric project, engineers and technicians will be needed to operate it, to construct the ensuing distribution systems and to organize the method of collecting payment for the services rendered to the consumers. Agricultural advisers and drainage engineers will be needed to ensure that suitable crops are grown by the techniques best suited to local conditions and that the land, irrigated artificially in this way, with a high water table, does not become too saline for continued cultivation. Experts can be provided by the technical assistance programme of the United Nations and they can do much to help in initiating the training of the local people, but major schemes will probably call for a concerted effort in training accompanied by the importation of some skilled people who can remain with the new scheme for some years until it is well under way. Suitable trainees must be sent to the more advanced countries which have had experience in the subject concerned. An incidental difficulty here is that trainees returning to a country where skilled people are few tend to become administrators or 'black-coated' workers of some kind in preference to doing the job for which they have been trained. This is a difficulty which must certainly be overcome. The essential job of such people is to train others, not to sit in an office perusing or signing documents.

Another important need in many arid zones is for much more information about the content and potentialities of these zones. Because, in the past, they have been so apparently useless, very little had been done to survey them. Geological and hydrological surveys are necessary to determine the amount and distribution of underground water and its salinity. The same surveys may reveal the existence of unsuspected reserves of useful minerals. Meteorological data are largely lacking because of the absence of observation stations in these areas. In general terms it is, of course, known that they are hot, sunny and dry but the actual intensities of solar radiation, the magnitude and extent of the sporadic rainfall, quantities of dew and the wind speeds experienced at different times of the year have been largely matters of guess-work. Yet these data might have a direct bearing upon the development of the area: they could give guidance on what might be grown and what possibilities

there were for producing power from the local energy resources of wind and solar radiation.

CONCLUSION

In spite of the many problems to which attention has been drawn there can be no doubt, first, that development of the extensive arid zones of the world is essential both to help their own scattered inhabitants and to make them more valuable to a world in which the continual pressure of rising population calls for more and more food. Second, this development can be achieved, but only through the really effective collaboration of all the parties concerned—the financing countries or organizations, the governments in receipt of aid and, by no means least in importance, the inhabitants themselves.

It must be a long process, demanding much patience and continued good will on the part of the development authorities, who must instil into uneducated, but not unintelligent, peoples something of their own enthusiasm for the improvement of living conditions and must show these peoples that the way of life they have followed for generations will have to undergo a change in their own interests. This is a most difficult task and those responsible for undertaking it must receive the sympathy and understanding of the peoples in the more advanced areas of the world who, in their turn, must be prepared to accept the changes which will inevitably take place as the arid zones begin to play an effective part in the world's economy.

MANAGEMENT IN A MODERN SCIENTIFIC AND TECHNOLOGICAL AGE

by

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INTRODUCTION

The scope of this article is to examine the impact of science and technology on management. It is not proposed to discuss the philosophy of management or question the aims: it is assumed that economic systems continue to exist and to require managements, and that the latter must constantly adapt themselves to rapidly changing factors. Nor is it proposed to give an expert analysis of education for management; the concept of 'management' as a separate discipline though of comparatively recent origin has developed rapidly, and a huge literature and specialist courses at all levels on the theory and practice of management are now commonplace. With it has also developed increasing controversy, but it is not the purpose of this article to marshal data available in accepted books of reference.

Thus the writer's aim is to point out from practical experience certain factors which seem important not only now, but particularly for the coming years. Preparation for the future deserves to be emphasized, for managers being trained today will have to deal with the events of the next quarter of a century —so that some attempt must be made to look ahead.

The essence of science and technology is the acceleration of change and the increase of novelty: the effects, however, depend also on local conditions. By and large, the highly developed areas such as Europe (including the United Kingdom) have a great many points of similarity, while at the other end of the scale in the underdeveloped countries conditions and problems are markedly different. It is proposed to deal with both groups. (In what follows the term 'science' will usually include 'technology', unless specific differentiation is made.)

A modern economically developed community depends for its continued functioning and expansion on management. To the latter, science and the scientists present both a challenge and an opportunity: these will be examined from two aspects, the human and the material, and in relation to a common target.

With the accelerating pace and growing complexity of scientific and technological development the securing of good results becomes increasingly difficult and more urgent. Management must therefore keep an ever-open mind and needs the power of quick mental cross-reference and adjustment. This complexity, and therefore the need for cross-reference, characterizes not only all the natural sciences, but applies also to the social sciences, including economics.

The scientist and technologist must understand that human nature does not function individually or collectively according to rigid formulæ: the scientific method can only be applied imperfectly and with caution. The non-scientist should learn that the principles and methods of science can be applied over a much wider range than that of a specialist. Perhaps the most important single issue facing education and management today, is to try to achieve a synthesis of the two, for there is no single method or solution, progress must be along a number of paths and will take time. In this respect, it is perhaps unfortunate that managers who have reached the top tend at times to be increasingly authoritarian, to the point of despising experts (perhaps from a false sense of prestige) and make decisions more and more 'off-the-cuff'; flair, in other words luck, may serve them well but this involves undue risk. On the other hand, too great care and precision may waste precious time.

In highly developed communities, progress in a given industry or field tends at first to be rapid, the curve then flattens as the limits of effective innovation are being reached, and finally stability, stagnation, and probably even decline, set in. However, there is the chance of a 'break-through'—which is advance in kind rather than in degree—bringing the curve of progress to a new starting point on a different level, so that growth can continue. It is the spotting, or creation, of these 'breaks-through' which must depend on the human element. They are the result of first identifying major needs and then applying creative imagination to designing the steps to meet them, or they may result from 'reduction to practice' through useful application of scientific discoveries. Both courses have the common factor of creative imagination, tempered, of course, by sound implementation. Thus progressive managements may often be groping for the break-through: it is here that the scientist and the manager, whether they are two persons or one, must act together. The first stage should be to start questioning and speculating on whether what has been done traditionally in the past is right in principle. After this, there must be an imaginative evaluation of what is possible under modern conditions and a creative leap forward to something which may be radically different. All this requires mental cross-reference and the power of creative thinking which are not easy for busy, efficient and conscientious managers dealing with day to day matters. For the scientist, however, to do this and to convince others, requires his acceptance as part of the management structure.

As modern capital equipment is very expensive, progressive managements

who feel that time may be ripe for a major change (i.e., a break-through) will try to postpone more conventional improvements, accumulate cash, and wait for the big opportunity: the scientist who spots or foreshadows the opportunity has a great task to perform. Here the difference of size of firm is relevant: a large firm has many items which can be shuffled backwards or forwards, increasing the range of choice, whereas smaller firms have to make the final choice earlier. Their venture into the novel, scientific and exciting is a much bolder step than for their bigger brethren. Since in most developed countries a large proportion of industry does in fact consist of the medium and smaller firms, their technological upgrading is the biggest single factor in economic progress: an attractive prospect for the scientifically trained manager!

A modern economy is a jigsaw of all kinds of human beings, thus human relations are an essential factor in management. The scientist who aspires to management must, in addition to being capable of clear and precise thought, be a good mixer, and should not imagine that making money is something indecent, or that creative thinking is confined to research. If science is to be useful it must have a marked impact on the lives of large communities: practical results depend on the successful interrelation of technological, commercial, financial and sociological factors and not on scientific achievement alone. For this, great specialization is not necessary: an appreciation of how the parts fit in, of the various factors affecting them, and to what extent, plus an appreciation of points of view and education other than scientific are important. Although many scientists mix in well with the rest of a firm's staff, effective mixing seems easier for those who also have a non-scientific education. 'Traditional' management with a commercial, administrative or financial education faces equal difficulties—a new generation of personnel and the inexorable fact that science is a hard taskmistress, requiring logical thought and the vigorous application of conclusions. There are still many distinguished and successful senior executives who dislike logical thinking and tend to act on intuition. They have often been right, but as processes become more complex and expensive, neglect of logic and hard facts, as well as the time factor, may expose them to the formidable danger of loss of crucial opportunities and risk of damaging failure. It is here that the objective and clear reasoning of the scientist, based on appreciation of all the factors and their presentation in simple plain language, could be of outstanding service.

SOME GENERAL CONSIDERATIONS

Although much of this article deals with British experience, a number of more general factors may first be considered. Modern science and technology—particularly bearing in mind advances over the next 25 years—can achieve virtually anything; one must not however be carried away with enthusiasm for, as a well-known scientist said to the writer, 'You can always make coal from

diamonds'. In a developed community, economics and sociology become closely interwoven, nor are politics an extraneous factor. (In the underdeveloped countries politics play an even greater part.) Thus cost, price and social consequences are highly important factors. Here the dangers of specialization arise: those concerned with commerce, finance or personnel administration may not understand and appreciate scientific and technological factors, while the scientists and technologists may be unaware of, ignore, or despise such mundane matters as costs, profits, or taxation. The need for mutual understanding is, however, being increasingly appreciated. In this respect a significant recent trend in the accountancy profession has been the search for new techniques for combining accountancy and management—accountancy being viewed not as a financial post-mortem, but as a tool for current control and the forecasting of the near future. A start has been made in this direction but tradition still holds sway and the 'marriage of convenience' between the accountant and the technologist is by no means yet arranged.

The often heard statement that the West is not producing enough scientists and technologists is true, but those who support the argument in favour of producing more are often motivated merely by the desire to catch up with Russia, which is turning out whole regiments of scientists and engineers, rather than by the positive motive of improving Western science and technology. To imitate Russia, however, would be to ignore certain vital differences between the present position and future trends there and in many Western countries. A country such as Russia has progressively increasing numbers in the younger age groups—consumers but not yet producers. Thus the ever-growing demand for basic needs—housing, communications, certain food supplies, clothing and so on—requires a huge and rapidly expanding 'infrastructure' before the other complexities of a modern civilization can be superimposed on it. For some time to come this 'infrastructure' must endeavour both to catch up with current requirements and provide for future expansion. Meanwhile, time will not wait, and increasingly large numbers of trained specialists are urgently required to deal with the various practical issues. Trained manpower is so short that all these specialists are easily absorbed, and the question of mental cross-reference or transition to new activities does not yet arise. Another similar manifestation—superficially paradoxical unless the root cause is understood—is the Russian urge towards 'automation' at all costs: the labour so displaced is immediately absorbed in expansion. This trend can continue for some time, because, according to the latest official Russian industrial planning figures, by 1965 only between 25 and 30 per cent of the population will be employed in industry, commerce and services—as compared with about 45 per cent in Britain today.

The position in many Western countries is radically different. In Britain, for instance, the population is almost static, with a growing number of elderly people and a slow rise in the total population—perhaps from 51 million at

present to 56 million in 25 years time. The 'infrastructure' though not yet fully adequate has little leeway to make up, so that the main problem must be the continued raising of the general standard of living, which means expansion of some activities, tapering off of others where the market becomes saturated, and constant introduction of new ones. All this points to a great deal of change and rapid adjustment—an all-important issue which British management must face in the years ahead. Fortunately, however, recent birth-rate trends make it likely that in the last quarter of this century the biggest numbers will be in the 30-40 age groups, i.e., particularly suitable for competent managers, if properly educated and trained.

Population trends are a major factor affecting every country, and require urgent study in the light of each country's circumstances. The effects on economics and sociology must profoundly influence industry, commerce and finance—and therefore the structure and methods of management. One implication of this is that each country should consider its age structure in formulating policy with regard to education and specialist training.

The so-called 'terms of trade', in which significant changes are likely to occur in the coming years are another dominant factor. Some world markets for standard lines of exports will contract as local production in the developing countries builds up. Meanwhile, world demand for raw materials will rapidly grow—through increasing offtake by the developed countries and more particularly because of the rising consumption in the underdeveloped as they progress. These trends will affect prices and therefore trade balances of countries which, like Britain, are dependent on international trade. But—taking the long view—the likely gradual rise in primary commodity prices will benefit, as nothing else can, the underdeveloped countries which rely mainly on this source for foreign currency. Supply prospects for certain raw materials may become poor, so that big price changes might occur, requiring switches from one material to another and adjustments of processing and design—often involving some drastic technological measures. These world economic factors will affect most industrial countries; it will be for managements to show the necessary foresight and take decisions.

The above may be called 'natural causes'. Equally, important is a man-made factor—the growing 'automation' in all sectors of industrialized communities, which will require profound changes of attitudes on the part of management and operatives alike. Not always will total numbers employed decrease—sometimes they may rise, but their character and distribution must change; thus redeployment, after retraining and regrading, must take place. In a developed community therefore technological progress means a dynamic state and the continuous creation of redundancies and their reabsorption, with all the concomittant economic and sociological consequences. Fortunately, since development and introduction of major technological changes of this type must take time, the human and material implications can be studied and

manpower changes planned so as to avoid undue dislocation. But the increasing pace of technological progress is shortening the time-factor and making reliance on delay dangerous. Public attitude towards this varies but on the whole neither organized labour nor indeed management has faced this issue squarely although in some instances it has been handled with conspicuous success. One example is the technological revolution progressively being carried out by the French National Railways; the scientific innovations involved not only drastic reductions but widespread regrading and retraining of manpower. A cardinal principle in planning the technological improvements was to take no steps until the manpower implications had been studied and careful provision made to reduce undesirable dislocations. That this complex schedule was maintained and successfully operated without much friction is a great tribute to management at all levels. It is noteworthy that those primarily concerned were relatively young and had a first-class education. Another example is the progressive nation-wide changeover of the British telephone system to fully automatic operation, including trunk and foreign calls. No significant redundancy is being created and the cadres of new specialist operators, supervisors and maintenance personnel are being trained *pari passu* with the new installations.

The increased demand for higher skills which technology generates poses the problem of the unskilled and particularly the untrainable. It is to be hoped that the percentage of the latter will be reduced through better education, but there may well be a group below minimum standard which will require special attention.

ILLUSTRATIONS FROM BRITAIN

Britain's structure and evolution are sufficiently typical of highly industrialized countries for practical illustrations from British experience to provide some useful general pointers.

Like those of the other old, highly developed countries, Britain's pattern is one of large, new, highly progressive industries dominated by big modern firms, and a wide range of old-established traditional craft-based industries, for the most part smaller or medium-sized firms. Problems of progress and therefore management differ markedly between these two broad groups. The upgrading of the second category in a modern scientifically-based manner would be of major benefit to the British economy.

These traditional industries in modern times have serious disadvantages. A considerable proportion of firms are not large enough to 'nurse' a variety of new projects until they can decide on the more profitable, but must make their choice at an early stage—thus greatly increasing the hazards of innovation. This restricted freedom of selection generates fear of publicity and secretiveness, i.e., the reverse of what should happen in times of rapid scientific

progress, when the maximum effort should be directed to finding new ideas and cross-checking experience. Suppliers of materials and equipment to manufacturing firms could be valuable sources of new ideas; unfortunately, however, many old-established British manufacturers of goods do not design or make the equipment they use, but rely on traditional makers of it. These, in their turn, have no say or interest in the making or selling of their clients' products. Each party considers the other knows its job, and it occurs to neither that the other could do better. Consequently, there has not been nearly enough cross-fertilization, or joint rethinking. There are now signs, however, that both are increasingly feeling for new concepts; a push-pull process has begun with the stronger stimulus coming from the consumer end. These industries are not 'glamorous' like the new science-based ones, they are under fierce competition (not least from the developing countries) and now, also, are affected by the issue of the Six and the Seven. All this has started basic questioning and rethinking—which are the first essential steps in the right direction.

Here arises immediately what is perhaps the most important human question for industry in Britain, where perhaps half the main industries are traditionally craft-based, as they are no doubt in several other European countries. Much of British output is for export, with quality as the hall-mark of craftsmanship: as export trends will inevitably involve the gradual abandonment of less high-grade products and concentration on specialities, the solution of the future export problem must depend on the maintenance of traditional craftsmanship in a successful marriage with modern technology.

Better designs, novel products, new ideas of production, quality control methods, new materials, etc., all are relevant. Specialities requiring a craftsmanship tradition usually demand short production runs and therefore conventional mass production methods using unskilled labour are inappropriate, and a low labour cost competitor's advantage is reduced. Automatic quality control does not suffice because occasional minor blemishes would condemn the whole product: e.g., very high grade cloth, in spite of the latest processing methods, still requires a two or even threefold final inspection by highly skilled operatives. At the other end of the scale, in precision engineering where only small numbers of each model are produced—e.g., the construction of complicated scientific instruments—both the original conceptions of design and the employment of high-skill precision tools are, in a sense, manifestations of the old craft tradition.

In this search for new concepts, two factors deserve particular attention, both *per se* and as affecting the craftsman's position. As indicated earlier, traditional production processes are capable of considerable improvement, but then the law of diminishing returns comes into operation, each successive refinement yielding a less significant result. The curve of progress flattens until the stage is reached when a drastic rethinking of methods of production or use must be carried out, so that a significant further advance can start from a

different level. To identify and then achieve what has been referred to as a 'break-through', is one of the most important and fascinating tasks of management. An example in the industries mentioned above is the search for ways of introducing a continuous flow into what are traditionally batch-type processes (e.g., textiles, leather, etc.). With continuous improvement these have become highly sophisticated, but are still mechanized imitations of the human operative. In newer industries such as chemicals or light assemblies continuous flow is standard, and now progressive thinking in the older industries is also seeking how best to substitute continuous flow for the traditional batch processes. The other factor is related to diversification and specialization: where should these start? Assuming that the aim is higher quality and more specialized end-products, is it better to standardize, i.e., to mass produce, almost to the last stage and try to diversify there, or to decide early and gradually build up divergent lines? Research and development targets, plant design, 'know-how', types of operatives, and management will all differ according to which of these policies is adopted.

The new generation of management now coming to the top has given a powerful impetus to this rethinking process in the traditional industries. They were very young when the war broke out, and during their years of service they saw for themselves in many parts of the world what science and technology could do. Much less parochially minded than their elders, who are now beginning to retire and hand over to them, they are determined to try and 'cash in' on what modern science offers. As they are not so bound by tradition, their ideas on ways of making or converting their goods or diversifying their activities are sometimes drastic. Thus a favourable climate all round for major changes seems now to exist. Let us take a few illustrations from typical traditional craft-based industries.

Preparation of hides and skins for tanning and their subsequent treatment, is universally carried out in simple robust machines, each hide being handled individually and involving much heavy dirty labour. Continuous flow was deemed impracticable because of the size and shape of the material and the speed variations for the different processes. Nevertheless, the attempt to introduce it may now be nearing success: automatically adjustable handling equipment, with sequence and speed controlled by simple yet robust electrical methods, was conceived by imaginative management, in consultation with experienced production engineers. The impetus was given by experience of efficient, yet relatively simple robust equipment used at sea and on land in war.

Two examples from the boot and shoe industry. Sequences of sewing operations to be carried out by operatives using high-speed machines in the manufacture of various styles of shoes are worked out centrally for each style. The components are then delivered automatically from (and returned to) a conveyor, at the positions of individual operatives designated in the proper

order on an electrically-operated pre-selector switchboard, the design for which was inspired by the bomb-selection panel of a World War II heavy bomber.

Application of automatic injection-moulding to mass production of plastic sandals, of the same shape and style as the particular firm's traditional leather sandals, required steel moulds to be designed exactly to fit the craft-made 'lasts' (i.e., wooden shapes) for the leather footwear. These moulds, arranged round a moving turntable, are injected in turn and the moulded sandals removed automatically, the speed of movement and length of injection time being controlled electrically by a pre-setting device actuating a hydraulic servo-mechanism. The latter is based on servo-mechanisms for aircraft, and was built by an engineering firm experienced in that field. The result is a cheap but well-shaped sandal which has tapped a very large new volume market which can only be satisfied by a speed and cost of production quite unattainable with sewn leather.

In both these cases, the original ideas came from executives with wartime aircraft experience.

In the textile industries, a significant postwar step forward is the so-called 'Ambler-Superdraft' for the spinning of wool: the device is based on mathematical thinking and consists of a small precise high-speed gear. Design and construction of this type of machinery did not exist in textile engineering, but the inventor, an air force officer of high rank, thought of a machine-gun type of mechanism and die-casting as a method of manufacture. The device was finally developed and produced by a firm in an entirely different field of industry, but accustomed to high-speed operations and small accurately fitting parts.

The above examples all illustrate bold and imaginative thinking by young and progressive managements, based on mental cross-reference from experience in other fields.

Finally, two examples of what might be called 'marginal' use of craftsmen —both in originally traditional, but now highly scientific, industries. In the manufacture of optical instruments, very fine accurate hairs are required in the eye-pieces, etc. Single filaments of spider's webs have the necessary fineness, uniform thickness, toughness and stability. The selection, 'harvesting' and subsequent storage and handling of these filaments is a craft job, requiring particular individual skill and experience.

The production of tinplate—a very old craft industry—is now wholly automatic, with continuous steel strip running rapidly through the pickling and tinning baths, followed by polishing, etc., cutting and automatic inspecting, prior to packing for delivery. The elaborate and expensive inspection mechanism classifies the product into prime, substandard and rejects, but so far no reasonably cheap automatic method has been evolved of assessing whether substandard material can be up-graded to near prime, or must go as

near-rejects (with a very big difference in price). A highly skilled and experienced operative is therefore employed for this; although the percentage of doubtful cases is small, nevertheless on so large a volume of output his results pay handsomely.

The soundness of managerial approach in both these cases is to be commended. However, as such craft specialities are rare, one wonders whether successors to the present incumbents can be trained.

Another and much more serious general problem is what to do with elderly craftsmen when such drastic changes of process or products occur that to retrain them would be impracticable. A useful and fruitful employment would be the development and construction of special 'one- or two-off' products or sub-assemblies, or the design of a mock-up or prototype of something new—i.e., where maximum skill and ingenuity are required, time is not particularly important and use of expensive machinery unjustified. This has been done by a number of firms, with good results and benefit to morale.

SOME HUMAN FACTORS

In recent years increasing efforts have been made to study the changes in human relations within and outside firms brought about by modern technological advances, and their sociological implications. Human relations in a rapidly changing industrial world are extremely important, but not to the exclusion of other factors: it is the interrelationship of all the factors which demands constant attention.

Among examples of this interest and the search for reliable information we might mention the field studies and investigations carried out by Dr. Joan Woodward, T. Burns, Professors C. Carter and B. Williams, to name only a few. No comprehensive guiding principles have yet emerged but quite a number of indicative factors have been identified; a few of these are referred to below as likely to have relevance, in the writer's experience, to a range of industrially developed countries.

A field study of the functions of management and management-operative relations in a mixed industrial and commercial area, was based on three types of modern factories: namely, those making single or a few-off products for customers' special requirements; those engaged in mass production and assembly from components; and those operating continuous automatically-controlled processes. These seem to impose quite distinct burdens on management and create particular patterns of management-operative relations.

The first type is customer-determined and for contract negotiation and product development, close liaison at all points between sales, design and production are required. Decisions are dictated mainly by local circumstances, so that policy and *ad hoc* problems are in a sense interlinked. Pressure on operatives is not marked and the skilled craftsman may be important.

In the second type, mass production policy is planned by top management away from the production line and *ad hoc* problem decisions on the shop floor are taken only occasionally. The product is settled in advance, and selling is a separate managerial function. Pressure on the production operatives is considerable because emphasis is on production efficiency, the competitive position depending on cost in relation to a pre-arranged price. Thus production management concentrates on command decisions on a narrow front, where time is expensive and argument at a discount. The operative often feels himself part of the production line; his attitude is expressed in the 'we' and 'they' formula and there is little sense of continuity between shifts.

The third type, the automatic process industry, presents a markedly different picture: the pattern is, in fact, dictated by the process. Managers and operatives are more closely knit because success depends on their common understanding of the process. Problems are rationalized quite early, so that junior management and also operatives can understand them, and delegation in case of need is thus relatively easy. Inasmuch as the process (unlike a mass production line) does not stop, there is a feeling of unity between all the shifts. Pressure is relatively slight, but the structure calls for a higher-grade intelligence and therefore probably generates a greater interest in the whole enterprise, which can counteract the boredom and fatigue associated with attentive watching of automatic dials.

Another field study (in the textile industry) illustrates the importance of sociological changes, some of them unexpected, brought about not only inside but outside the factory by technological innovation. A concern had two similar factories, in two almost identical small towns where the firm was the main employer. One factory changed over to modern automatic weaving and shift working, the other still used the traditional looms. In the first case hierarchies, not only in the factory but in the town, were somewhat surprisingly upset. Traditionally, the weaver in charge of a set of looms was a craftsman, and therefore an aristocrat in the operatives' hierarchy, whereas the maintenance man for the old-fashioned loom would rank only as a cleaner of low status. With modern automatic looms the weaver had much less to do, his output was much bigger, and his earnings better, but no longer did the quality of the product depend on him. The maintenance man, on the contrary, became a skilled technician concerned with output, quality and quantity. Thus, their roles and status were reversed, as was the status of their wives in local society. Furthermore, division between operatives who worked shifts and management and office staff who worked by day became marked, with bad effect on morale and relations. It was thus deemed politic for managers, including even executive directors, to appear occasionally on night shift, though there was nothing tangible for them to do.

Night work for women is at present not allowed in Britain. Under full employment, however, since female labour is in demand and modern high-speed

machinery requires shift working, the 'double-day' system—two shifts, from about 6 a.m. to 10 p.m.—is frequently adopted. Women seem to approve of this, but preference of shift varies according to local habits and to whether the women are married or single. Some attitudes are found to be the opposite of what might have been expected, bringing home the lesson that not nearly enough is known about operatives' habits and motives, and that management must in the future increasingly study the human aspect, particularly as the growing shortage of manpower and the rising average age of the population will necessitate the employment of more married women and elderly people.

THE UNDERDEVELOPED AREAS

There is much glib talk about development of underdeveloped areas, and it is constantly repeated that the accumulated technical and administrative 'know-how' of the West in the form of expert manpower and training facilities should be used. It is usually assumed that the principles and practice of organization and administration of developed countries will be applicable; but this not infrequently results in delay, frustration or failure, for there are, in fact, considerable differences in background philosophy, rooted tradition, current theory and practice. To discuss these would require a separate treatise, but a few salient points are set out below, as of likely relevance to the particular problem of management in industrial development projects.

First and foremost the industrial structure usually found in developed countries and its relationship to public administration and the mass of the population are by no means the pattern. It is much more likely that the following sequence will be found: survey of development possibilities (i.e., consultancy), expert advice to local executives or government, specialist appointments (i.e., 'staff' as opposed to 'line'), and finally project contracting. All this is set against a background usually totally lacking in the slow organic growth of an industrialized society, but often with strong and systematic traditions of its own.

It is a commonplace error to classify territories simply as 'underdeveloped', ignoring the important distinction between 'independent' and 'emerging' countries. The former have an established administration and national policies, and would require technical (and commercial) expert assistance but within their own political framework. The emerging countries need to train and build up their own administration and acquire an independent political and social outlook, at the same time as developing an economic system. The first category thus primarily requires specific expert advice, the second needs the training of its nationals to take responsibility.

When 'expert' surveys of a given territory are carried out, only too often the approach and evaluation are based on the premises and practice of developed communities: as mentioned earlier even for the latter preconceived ideas can be severely battered by reality. On the other hand, information on local

practical experience in one underdeveloped area is often unavailable to another where it could be very useful. This is partly because those concerned are relatively few, engrossed in their work and lack facilities for systematically recording and making known their experiences, but partly also due to the political undertone associated with the idea that because a territory is (still) underdeveloped, therefore those in charge are retrograde, their experience not worth much and an 'enlightened' outside approach is needed. All these factors will profoundly affect 'managers', i.e., those who assist in surveys, advise, organize and direct development projects or operate industrial undertakings, and train local personnel. Their activities will in the last analysis depend on the territories' administration; the more so because industrial development will both create the need for an expanding administration and help to satisfy it. Here again, however, the relationship will often differ from that in an industrial country, where the 'infrastructure' for industrial enterprises—sites, transport services, energy supplies, etc.—already exists. In an underdeveloped territory, this infrastructure has to be first created wholly or in part by the administration, which thus becomes in a sense partner in the subsequent industrial ventures. Industrial firms are now increasingly realizing their responsibilities and trying to instruct their overseas managers accordingly.

In the above general picture, whatever his function, the 'manager', for want of a better general term, must at the outset get the general 'feel' of the area, its population and its problems; not only of the particular project, or aspect of it on which he is engaged, but how the project must fit into the life of the country, what effect it will have on that life, and also what the general conditions are while it is being pursued. In this respect, differences between 'line' and 'staff' are unimportant. To give an example: big hydroelectric schemes (e.g., Kariba Gorge) leading to elimination of some areas, planned irrigation of others and the establishment of industries, would involve the rapid removal of a tribal population from its territories, and its resettlement in modern communities, with all the consequences which this would entail. Thereafter, this population would have to be educated to accept and take part in industrial activities. In a modern society such upheavals would be tackled by an army of experts in all aspects whereas those in charge in an underdeveloped area would be comparatively few—so must see each other's problems and endeavour to cover the whole field. This may be termed 'community development' and is a powerful factor in training local initiative and responsibility; the 'foreign' manager can play an important part.

As already mentioned, when sovereignty is exercised by an established national government, it employs foreign advisers or foreign contractors to carry out its plans. In such cases, the extent to which procedures of developed countries can be applied is usually limited at first and managers must study not only the qualifications for acting as advisers and being at the same time, in a sense, responsible; but they must also discover what standards can be expected

in the locality. The principal aim is not so much attainment of efficiency according to a sophisticated tradition, as the achievement of results within a local framework, so that from practical precepts gradually a tradition can be built up. This entails training of the local personnel under gradually modified local conditions, and inculcating in those who take training abroad that it is not the conditions they find abroad, but what they will find when they come home which matter. Outstandingly successful examples of such projects are the Sindri fertilizer and Durgapur steel projects in India, where 'foreign' expert managements fully assimilated local circumstances and wholeheartedly set out to weld their own and local efforts into a single whole.

Quite often, however, the objective is to assess local needs in order of priorities, starting with the simplest. The technological problem is not so much to install complicated machinery and then find personnel to operate and maintain it, but to think out modern production problems in terms of the possibility of breaking them down into the simplest and most foolproof component jobs which could then safely be entrusted to unskilled personnel with no industrial tradition. This is a problem not only of machinery design but also of factory layout and managerial and operatives structure. It is here that so many expert surveys fail because the criteria applied are either those of technical and managerial competence based on industrially developed standards, or the approach is a purely theoretical, political, sociological and economic one without concentration on what is actually practicable. In general the principle of 'make do and mend' is sound: to establish in which fields half a loaf is better than no bread, and build accordingly on what human resources and materials can be made available. This principle, incidentally, has been consistently adopted by Russia—even well before the 1917 revolution—and is one of the reasons for its great recent successes and the ease in its dealings with underdeveloped territories.

ASPECTS OF EDUCATION AND TRAINING

Before considering under three specific headings the various factors likely to affect management over the next 25 years it seems worth considering a more general question.

The imperative need for mental cross-reference raises immediately an important educational principle. In Britain, for instance, specialization in science and technology starts quite early in the secondary schools—with the risk of water-tight compartmentalization. There may be a further concealed danger here: if too many are trained with management in view, or again as narrow scientific specialists, the growing demand for supporting personnel, e.g. technicians, might not be met. One may ask whether a Continental system, such as the German *Abitur*, might be not more appropriate since it gives a broad general education at a fairly high level in all branches, and enables

efficient specialization to take place at the universities and colleges of technology. The price to be paid for this might be a longer total education period. Various experiments being carried out to broaden education at present in Britain in first degree specialist courses, and mixed university honours courses—e.g., science and economics or engineering and economics, refresher courses after graduation, etc.—point to this dilemma. (It is interesting to note that in Russia, although specialization in higher education is intense, the secondary school system preparing for it seems, in fact, to be based on the *Abitur* principle.)

We shall now turn to the three main groups—managers, operatives and the public.

Managers. As the general level of education rises and highly developed communities become more complex, the power of mental cross-reference and ability to cope with the still unknown—and perhaps startling—problems and opportunities of the future must grow in advance of need; and at the same time the output of scientifically educated and expertly trained managers must be maintained. The urgency of these matters has been recognized in Britain in recent years: appropriate courses have been introduced into higher education curricula, and all sorts of postgraduate, refresher, and training courses in various aspects of management and at all levels have been—and are constantly being—set up in universities, polytechnics, technical colleges, specialist institutes, and by professional bodies, in close co-operation with industry, commerce and finance, and including courses run by individual firms themselves. The list of available facilities is formidable—occupying 287 pages of the latest issue of the British Institute of Management's reference book. It is not proposed here to discuss this or to draw comparisons with other countries, but only to mention a few significant points. Of course, such institutions for higher management training as the Administrative Staff College at Henley (or, say, the Harvard School of Management in the USA) cater for only a tiny fraction of managers and only the big firms—a relatively small proportion of industry and commerce—can run their own courses. Thus, by far the heaviest load of training the medium and lower levels and catering for the smaller firms is in Britain borne by the technical colleges and similar institutions. The picture which emerges is one of ferment, with a bewildering diversity of aims, subjects, methods and evaluation and, as yet, no unifying coherent policy. After an initial flush of enthusiasm, there is increasing questioning of the objectives, and doubts are being cast on some of the alleged principles and methods of education for management: much of the earlier approach was *a priori*, and field studies to test hypotheses were sketchy or non-existent, so that a great deal of work was based on 'hunches'—resulting in the diversity mentioned above. Even the main issue whether management training is given primarily to assist managers in self-development or to teach them management techniques is

still unresolved. Opinion is now inclining towards the first interpretation, but the question arises whether, if the potentialities for self-development are there, they would not appear in any case; it is further held that the imparting of techniques at least improves those without the requisite potentialities. A proper assessment of these questions belongs properly to the field of human sciences which are still in the early stages of development, but sociological investigations are upsetting previous ideas and emphasizing the need for a much more organic and functional approach—at least until enough data have been collected to enable reliable principles to emerge, at which time systematic attempts must be made to identify and evaluate them.

Industry, commerce and finance, are increasingly accepting the need for educated and trained managers, but there also exists the real fear that by giving the 'scientist' (including the 'human scientist') too much power the hierarchy of management will be undermined. This is yet another warning against too narrow specialization, and *a priori* assertions.

Operatives. With the progressive raising of the school leaving age and the multiplication of opportunities for further instruction (as well as changes in traditional apprentice training), a more ambitious and probably more restless young intake into industry will result. While accepting the need, they will not be persuaded that aligning accurately four bolts in sub-assemblies on a conveyor belt, for example, is *the* important thing in life. But this attitude and the greater opportunities to 'better themselves' carry new obligations of flexibility in job transfer and willingness and ability to undergo re-training. So-called 'automation' not only demands a higher general standard of skill, but also a change from a manipulative skill to an appreciation of how the job fits into the general factory scheme. But even if the average educational level can gradually be raised, there will still be numbers of the low-grade to whom little can be offered other than unskilled jobs. The gap between these and the higher-grade demands of modern trends in production and services will grow wider; modern management therefore faces the task of avoiding a division into those 'above' and 'below the salt'—with all its sociological implications.

The public. Not only advancing education, but radio, and especially television with its give-and-take discussions of current problems, are building up a much more informed electorate, distinctly less prone to accept uncritically a 'hand-out', or *ex parte* decision or point of view. Politico-economic and sociological questions thus will require increasingly careful handling and neither an old-fashioned paternalism nor a modern soulless bureaucracy, however efficient, are likely to be accepted in industry and trade without question; the pressure of wives and parents, particularly if they know how to work the machine of local and central politics and are aware of the advantages of the Welfare State, can be very powerful.

To sum up, given a reasonable educational background, managers should be trained by being taught to think out how to solve their problems, rather than be told the solutions. This will demand of the scientist a serious study of commercial and human factors, and of the non-scientist an effort to grasp how science and technology inevitably effect economics. Such training should be related to the actual situations in the industry or firm concerned, otherwise contact will be lost, and the fatal tendency to 'talk at', or 'talk down' from some (unspecified) superior level will develop. Training opportunities for self-development of managers are probably, in fact, more important than training techniques as such. Selection, careful supervision and organization of training, the whole integrated into the general scheme of things of the firm or group, must thus be the duty of management starting from the highest level downwards and should be tackled whole-heartedly and with enthusiasm. At the same time, those studying so-called 'management' or 'industrial administration' as an academic subject might well be urged to be less 'academic'. A determined effort should also be made to capitalize on the now increasingly numerous field studies and to evolve some common deductions from them, regarding them as raw material for policy and practice and not, as often happens, as a means of obtaining research degrees.

SOME ORGANIZATIONAL AND FINANCIAL FACTORS

The keynote of the modern technological age is accelerating change which, as has been emphasized throughout the present article, is the dominating problem for managers, particularly with reference to the old-established traditional industries. Some economic purists will say that obsolete industries must go to the wall, and that the future is for the modern and scientifically based ones, for which ample finance should be made available. This is an over-simplification of the problem and, in any case, a wholly impracticable solution, because the resultant economic and social dislocations would not be accepted by the public.

The challenge to management to harness science and technology to the needs of such industries thus becomes all the more greater. Clearly, some assessment of the factors involved and establishment of priorities for available resources are necessary first; those who believe in a directed economy would advocate comprehensive planning and control from the centre. In a country such as Russia or China, rigid central planning can be imposed, because all the economic variables, quantitatively and qualitatively are under direct control, and consumption, investment, movement of population, and so on, can be enforced. It should be remembered, however, that these countries are still a very long way off full development—and no one knows what will happen when there is sufficient of life's necessities for everyone and consumer preference begins to play a part. While it is true that in some countries—notably

Holland—a skeleton short-term economic plan is drawn up annually, it is extremely doubtful whether comprehensive longer-term planning is possible in a complex highly developed democratic society under dynamic conditions of rapid change. It is quite clear that any such planning cannot replace judgement and adaptability. What can and should be done, however, is to identify and assess a number of factors which are likely to affect long-term trends—e.g., size of population, limits of fuel and power resources, resources of raw materials, land available for cultivation, and so on. Such enduring factors, if properly assessed and related to short-term changes and opportunities by an educated and alert management, will profoundly affect a given situation and the immediate prospects. To forget or ignore this can spell trouble: a striking illustration of how a short-term view based on an attempt at elaborate economic planning can go wrong is the present fuel situation, which is similar in Britain and Europe. Taking prospective fuel demands over the next 20 years with rising prosperity, a big and steady increase was (quite rightly) forecast, and a marked prospective shortage resulted when compared with anticipated supplies. Practical plans for coal production and vigorous atomic energy expansion were based accordingly. A number of factors then came into play: a short-term slackening in industrial expansion (already overcome); steady improvement in efficiency of fuel use (stimulated by the prospective shortage), greater availability of oil and natural gas than immediately expected, sales resistance to rising coal prices—with the result that intelligent consumer choice went for the more convenient and economic liquid and gaseous fuels to the detriment of coal. On the whole the estimate of long-term growing demand for energy still applies, but it is clear that short-term trends are much more conditioned by technical and economic factors intelligently exploited by progressive managements, than they are influenced by elaborate statistical forecasts. It could be argued that authoritative central planning would overcome this, e.g., by enforcing the use of coal to prevent dislocation in the mining community, but would this uneconomic brake on the rest of industry really be to over-all advantage? Is not the solution rather the constant urgent study of such qualitative factors as convenience and cost advantages, leading to the progressive conversion of coal into fluid fuels and electrical energy? While this presents a challenge to management to balance all the various factors, it also challenges organized labour, because with the increasing speed of the development and adoption of novelties (some of them perhaps introducing drastic change) less time is left for the manpower planning involved.

Whatever the political arguments for or against price regulation, subsidies, etc., for public services or nationally essential industries, from the standpoint of management the criteria of economic efficiency and the cost price relationship will continue to dominate. Science and technology have not fundamentally altered these, although they have made their application more complex, so

that perhaps a new approach is required from the financial point of view. As mentioned earlier, the biggest challenge in the coming years—and probably the biggest field for significant economic progress without intrusion of politics—will be the medium and smaller sized firms. Not only are they unable to diversify risks, but also with the growing complexity of technology they are faced with frequent 'straddling' problems, affecting more than one firm and sometimes more than one industry. (Examples would be an engineering process supplied by one type of firm, requiring a sophisticated automatic control depending on quite another branch of engineering; or the novel use of a chemically-based material, e.g., substitution of plastics for metal; or, again, the undertaking of an expensive and entirely new process approach. At times a single firm will be unable to cope, and a group of complementary interests would have to be constituted. This implies co-operation—which would run strongly against individualism and the tradition of secrecy which still exists in some British and foreign sectors of industry.)

In the future, a problem of choice is likely to arise more and more often: should control of design and production be from the product or from the process end. In other words, are the advantages of a new (and expensive) technological process such that, in a sense, the type of product will be determined by the process, once it is installed? Or is reliance to be on marketing, with flexibility, and the production policy determined thereby? For large units in certain industries, the pattern is already decided, but as science and technology spread to the smaller firms this dilemma will become more common. It is here that the new 'management accountancy' could serve a useful purpose. In considering an expensive new process, not only must the 'pay-out' time of the capital to be invested be assessed, but also the dislocation (which might be considerable) due to the change-over, with loss of quality and goodwill in the market. As far as these are tangible, they must be added to the pay-out time of the new venture. An interesting particular instance of this has been experienced in Britain in connexion with the installation of new machines, of which individual units of revolutionary novel design have been proved, but of which there can be no proper economic assessment without installing a battery of them to run in comparison with an existing battery of traditional machines. The risks are considerable: capital cost of a battery is high, and the possible dislocation to production, loss of goodwill, etc., unknown. Therefore, even a fairly large user may hesitate before undertaking the risk, while the manufacturer of the new equipment cannot always be expected to lock up so much of his own capital on a 'sale or return' basis. The more science and technology advance, the more radical new designs are likely to be, and the more likely this state of affairs to occur. There seems to be a financial gap here which could only be bridged by a co-operative effort on the part of the manufacturer, the user, and a finance house, to underwrite a portion of the risk. Some novel thinking will be required from all concerned, for no single person can assess

all the factors of technological excellence, economic acceptability within a user/manufacturer pattern, and financial risk.

Another possible financial gap is faced by the small, progressive, but specialized firm successfully and rapidly expanding into a novel field, and thus requiring substantial additional capital. The usual provider of finance does not know the field—because it is so new—nor has the firm a long back history (because it is young and small) on which to base financial judgement. A serious managerial dilemma must arise in finance houses catering for this sort of demand. The first essential step would be for the parties to talk the same language: those wishing to push ahead with novelty must be able to explain convincingly their reasons to the financiers, and the latter must satisfy the potential clients of the relevance of the financial criteria put forward. In Britain there is probably less knowledge in industry of the availability and flexibility of financial resources than on the Continent—where there is a longer tradition of 'combined operations' of industrial enterprise and finance under changing conditions.

SUMMARY AND CONCLUSIONS

New achievements of science and technology are causing rapid expansion in the number and scope of opportunities and alternatives. This process will inevitably introduce profound changes in managerial structures and raise new financial problems. Thus a decision to adopt a modern sophisticated technological process raises from the outset the question of traditional organization, and the introduction of specialist techniques gives rise to profound changes in management hierarchy. Complete 'automation', especially, may well require a reorientation of managerial attitude from essentially controlling separate operations to appreciation of the new technology as an integral organic part of the enterprise as a whole, with consequent assumption of new responsibilities.

Economic and social changes—sometimes drastic—caused by technological progress in expanding fields can usually be planned ahead and carried out without undue difficulty: in static or declining markets, however, this problem may be formidable. In the former case, management has to provide in advance for increasing demand of special skills, in a framework of widening opportunity; whereas when an activity is tending to flatten or decline, technological improvements must be related to cutting back of recruiting and reliance on natural manpower run-out, just at the time when the technological novelty may call for vigorous new blood.

New techno-economic complexities will require a novel, more varied and flexible financial approach: the new 'management accountancy' and budget forecasting point the way. This technique can be a most useful tool for managers but will also apply constant pressure on them. Those who feel themselves failing to achieve results will be hostile to it, and will try to escape direct

responsibility by applying pressure on those below: one should be forewarned against development of such stresses.

The idea that if scientists and technologists gravitate into management and away from their direct specialities, they are wasted, is a profound mistake: every opportunity for cross-fertilization must be encouraged, and a higher management with knowledge and experience of both sides—the commercial and the scientific—can only be a gain.

In the last analysis, the function of management is to try to know and understand how the human mind works: as science and technology advance, so the factors affecting such working multiply and diversify, but so also do the means of finding out and taking appropriate action. But all will depend on human decisions.

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